THE PROBLEMS OF HEREDITY

BY

Dr. É. APERT

Principal of Andral Hospital, Paris,
Secretary General of La Société Française d'Eugenique

FROM THE SMITHSONIAN REPORT FOR 1913, PAGES 397–413

(Publication 2293)

WASHINGTON
GOVERNMENT PRINTING OFFICE
1914

THE PROBLEMS OF HEREDITY

BY

DR. E. APERT

Principal of Andral Hospital, Paris,
Secretary General of La Société Française d'Eugenique

FROM THE SMITHSONIAN REPORT FOR 1913, PAGES 397–413

(PUBLICATION 2293)

WASHINGTON
GOVERNMENT PRINTING OFFICE
1914

THE PROBLEMS OF HEREDITY.[1]

By Dr. E. Apert,[2]

Principal at Andral Hospital, Paris, Secretary General of La Société française d'Eugenique.

It is my pleasure to address you, ladies, on a most attractive subject—heredity. What is more interesting than to study a child's physical, intellectual, and moral resemblance to either of its parents (direct heredity), to its more or less remote ancestors (atavic heredity), or to its uncles, aunts, male or female cousins (collateral heredity)? What is more enthusing than to search out the reason why and how this resemblance is brought about? And yet it was with some hesitancy that I accepted an invitation to speak to you on this subject. I feared to impose upon you, at least in the second part of my address, some difficult, abstruse, mathematical explanations, compelling me to put before you some rather formidable looking algebraic symbols, which will demand your closest attention. If I consent to talk to you of heredity, as I have been obliged to do for a dozen years, it certainly would not do for me to tell you of curious and amusing facts without giving other explanations than unverified theories. We are beyond that, and you would have me at once make you acquainted with recent advances; the result of experimental studies on animals and plants and their explanation requires a knowledge of natural history ideas and of general biology which I will be obliged to recall to you; but these discoveries are applicable just as much to the human species as to the more humble animals and plants. I will therefore explain them to you in detail.

I would, perhaps, have passed over in silence that most difficult part of the subject if I had been called to speak before a frivolous worldly audience. But I have before me here an assembly of the very highest type. I know that you are ladylike women who do not wish a lecturer to divert or amuse you, but to instruct you. You come here to acquire knowledge which will enable you to be useful to all, to your surroundings, to your neighbors, to your country. Every day you prove that you do not fear the trouble you take. It is not much to exact a little attention from you, since you do not dread the

---

[1] Translated by permission, with author's revision, from Revue Scientifique, Paris, July 12, 1913.

[2] Lecture before "l'Union des Femmes de France" (French Red Cross).

difficult care of the sick or injured, the dressing of wounds, the groans of those operated upon, or the death rattle of the dying. I recall that several of your members are at this moment on the field of battle, and have no fear of facing climatic dangers and enduring hardships even unto death.

You know that the laws of heredity are susceptible of happy applications in the human species, so that you will not doubt, I am sure, some explanations that I shall give as briefly and as clearly as it is possible for me to do.

Heredity. What is meant by that word? You know what it is. It is a fact of daily occurrence, that the descendants reproduce more or less completely certain peculiarities which existed in one or the other of their ancestors.

There is right here a point of observation so universal, so generally known, that it is never overlooked, after the birth of a new-born child, to ask who it resembles. Is it the father? Is it the mother? Generally, persons who have known the father as a child are of the opinion that the newly born is exactly like its father at the same age. On the other hand, those who knew the mother do not hesitate to say, "But no; that little mouth, those large eyes, are they not its mother's? There is a most striking resemblance." In reality both of these observations are correct, and we shall see that mathematically the child has exactly one-half of the characteristics coming from the paternal and one-half from the maternal line. If, in certain cases, very rare, however, the child seems to have inherited more from one side than the other, it is because certain characteristics are susceptible of remaining latent, masked, invisible; but they exist none the less, and generally these latent characteristics include some paternal and some maternal characteristics, so that in the great majority of cases the child after all is an equal mixture of both parties, a mixture sometimes happy, sometimes, alas, unfortunate. It is these unfortunate cases that a knowledge of the laws of heredity may in some degree restrain.

Heredity bears not only on the features but on the physical characteristics, the build, weight, tints of the skin, the eyes, the hair, etc. It rules also the intellectual side, the morals, morbidness, etc.—in a word, all that constitutes individuality.

Certain individual characteristics may be transmitted for many generations. The ancients have preserved to us the history of this transmission in the Cicero and Lentulus families by some marks on their countenances, to which they owe their name ("cicer," chick-pea; "lentulus," lentil). In the same way a lock of white hair at the middle of the forehead of the youth was for a long time transmitted, they tell us, in the family of the Rohans. But these family characteristics are not long in disappearing, which can be understood,

for at each generation the women are carrying half of an hereditary element which is exempt from the peculiarity. The extraordinary part of it is that in the cases cited these peculiarities have not disappeared sooner.

On the other hand, it is very natural that some peculiarities should be perpetuated where marriages take place within a limited circle and where the same families constantly intermarry for several generations. This is seen in certain regions, but the facility of intercommunication tends, however, to render such conditions more and more difficult. The populations of certain of our coast islands (Ouessant, Brehat) have for that reason taken on a special type. Nearly all the inhabitants of a valley in the high Alps show what they call sex digitism; that is, an extra finger and toe. Emigration toward the cities has caused these people to disappear. Sometimes certain family groups are found isolated from the rest of the population not only by geographical obstacles but by their costumes, manners, and differences of religion. They may begin to take on a certain type even when they are primitively of the same race. Thus the Mohammedans of China, who are not immigrants, but pure Chinese, have a special type of feature; the Parsees of India, who are of the same Indo-European race as the Brahmans, are of a type very different from them; the Polish Jews, who are not the immigrant Israelites, but who are descended from tribes converted during the tenth century of our era, partly to Christianity, partly to Judaism, have ended by separating themselves from their brothers, the Polish Catholics, not only in their physical characteristics and their intellectual aptitudes but also by their special disposition to certain diseases peculiar to them and which form part of a group of familiar nervous maladies that I will mention in a moment.

There is a group of families which have intermarried almost exclusively for nearly 1,000 years. They are the royal families of Europe. This group presents a very important and particularly interesting subject of study on account of the quality of the persons composing it and because of the facility with which their history and even their portraits can be traced back to a very early period. In a highly authoritative work Mons. Galippe has brought together more than 200 portraits of members of the royal houses of France, Spain, Austria, Bavaria, and Savoy, who have united with each other by repeated marriages in nearly every generation. It is easy to see that a family resemblance was very quickly manifested. It is characterized principally by two peculiarities, the arched nose, the Bourbon nose, which is found not alone among the Bourbons, but among the royalty of all the Catholic thrones of Europe, and also the projection of the very heavy lower jaw, the teeth projecting over those of the upper jaw. The portrait of Philip II of Spain at the Louvre

and the portraits of Charles V show this peculiarity most strongly, and it is still found more or less characterized in the great majority of members of royal families, as much among the great houses that we have mentioned as on the small thrones of more recent foundation where they are at once fixed by repeated alliances.

You see, *the peculiarities persist in successive generations only when they exist at the same time in the paternal and maternal ancestors.* In the inverse case they rapidly disappear.

In what concerns the intellectual faculties we reach the same conclusions. We could cite numerous examples of families where the same order of talents has appeared among several members. Among literateurs, the two Plinys (uncle and nephew), Seneca and his nephew Lucien, the two Corneille brothers and their nephew Fontenelle, the two Chénier brothers, the two Musset brothers, the two Alexandre Dumas, father and son, and many others. Among learned men we find the physicists Becquerel, grandfather, father, son, and grandson; the mathematicians Bernouilli, uncle and three nephews or grandnephews, and the naturalists Geoffroy-Saint-Hilaire, Isodore and Etienne, father and son. Among painters are the three Vernet, Carl, Joseph, and Horace. We could lengthen the list very much, but the persistency of high talent seldom persists more than three generations. In order that this may be otherwise, the inheritance of a certain talent must be maintained by the union of families equally endowed. We could mention several examples of this. Thus the Darwin and the Galton families, both of which include eminent naturalists, have been thus united repeatedly. Here we find the persistence of remarkable faculties relative to natural history for five generations, since Erasmus and Robert Darwin, both naturalists of high merit, grandfather and father of the illustrious Charles Darwin, down to the sons and grandsons of the latter, one of whom, George, has recently died after achieving some remarkable work in natural history, and another, Leonard Darwin, who presided recently at the meeting of the Eugenic Congress in London. The Galtons likewise were perpetuated by Sir Francis Galton, grandson of Charles Darwin through his mother. It was he who founded the Eugenic Laboratory of London, and accumulated numerous works on heredity, from which the greater part of the facts that I will relate to you are borrowed.

The most beautiful example of mental heredity is that of the Bach family, the musicians. The beginner was Veit Bach, a baker at Presbourg, who refreshed himself after his toil by his songs and music. He had two sons, who commenced that unbroken line of musicians of the same name which spread over Thuringe, Saxony, and Franconia for nearly two centuries. Fifty-seven musicians of that family

have left a record and twenty-nine are mentioned by Galton as eminent musicians.

The Bachs contracted numerous marriages for their daughters with former music masters, organists, and town musicians, as the custom of the body corporate at that time permitted. Those frequent marriages among musicians could not help having great influence upon the musical talent of their offspring, and this, says Mr. Ribot, is one of the most beautiful examples of artificial or natural selection that one would find in the human species.

We now come to heredity of moral characteristics. Morality is transmitted in families; an honest father and mother have good sons and daughters. Of course education and good example have their share in it, but so also does heredity. Inversely, bad principles are transmitted in families, and we read in every book on heredity the history of that mendicant who arrived in the English colonies of America in the early days of their colonization, and who, endowed with all vices—a drunkard, a thief, and debauched—had passed half of her long life in prison. She had had numerous children, and in looking over the civil archives of the State and also those of the galleys and prisons we can safely state that among several hundred of her descendants four-fifths were delinquents for misdeeds of various kinds and a dozen had ended their lives on the gallows.

Permit me here one digression. It suggests a subject which has been much considered—that of responsibility. Since tendency to crime is inherited, since there are born criminals, are they responsible for their crime, and should they be punished? Are they responsible? The question should be considered from two very different standpoints. There is the philosophical point of view. It is possible that from that view, we might say that responsibility does not exist, for all our acts are determined by causes and that our will is only an illusion. I will not discuss this, for centuries since the time of ancient philosophers have not sufficed to settle it, and I have no desire to enter into the controversy of the free will, of the efficient cause, and the determining of our acts. That phase of the question, however, ought by no means prevent us from responding when we consider the practical point of view. On this side the more the delinquent has acted through the fact of tendency due either to heredity, environment, or to education, the greater the need that he fear chastisement, for it is only such fear that restrains the immorally born person. The accidental delinquent should certainly be punished, but his punishment is not a social necessity; for the punishment of being a born criminal is forced upon him; it is rendering him a service to furnish him the only reason that he has for struggling against his bad instincts. The only irresponsible beings are delinquents who have

lost all consciousness of their acts, epileptics for example, who in their normal state have no recollection of what they may have done during their frenzy, and also certain insane persons. There remains for me the discussion of the inheritance of diseases, an interesting phase of the question of heredity, because of its many practical and important applications. We should distinguish, on the one hand, between inherited maladies, known as family diseases, which seem to have no other cause than that of heredity, and, on the other hand, the much more common illness where heredity plays only a predisposed or accessory part and is merely a factor among other more active and more important agents.

Charcot has described, under the name of "family maladies," certain affections of the nervous system; they habitually attack a considerable proportion of the same family (25 or 50 per cent). They take similar form and a like evolution with each of the stricken subjects. They appear among these persons as the result of taint originally from a germ, becoming manifest through their development and independent of all exterior action.

Since these first works of Charcot, the known number of diseases with these characteristics has very much increased. Many family affections are now known, not only of the nervous system but of all organs of the body. These family maladies are transmitted in families in the same manner as morphological characteristics; they are inherited under the same laws as malformation, such as the sixth digit, already mentioned. As to malformations, they may pertain more particularly to certain countries, certain races, and certain groups of people, and especially to groups of people isolated by their geographical locations or by their matrimonial customs. There is nothing strange in the way that these malformations are manifest, for they are the result of veritable inherited malformations. Thus, there is a family disease called "l'atrophie papillaire familiale," and which, with very few exceptions, attacks men only; the women of these families are almost always exempt, and I will tell you to what this happy privilege is due. The children of these families are born normal and grow up full of health, but toward the age of 25 the sight of some of them begins to weaken; if they consult an ophthalmologist he discovers, after exploring the depth of the eye, an atrophy of the central bundles of the optic nerve and, in spite of all that can be done, that weakness progresses until there is almost a complete loss of sight. One is led to believe that the disease comes from some special physical defect—to an exaggerated narrowness of the cavity where the optic nerve leaves the cranium. This cavity remains in a fibro-cartilagenous condition during childhood; in men the ossification of the circumference of the orifice is completed toward the age of 25; but in women it more often remains incomplete. The malady

is, then, the result of a gross, anatomical malformation. All family diseases thus have for their origin an hereditary malformation, though often it is not so easily revealed and is discovered only by microscopically examining the inmost of the tissues. But in either case it is a question of the transmission of a special defect, and there is nothing wonderful in the fact that it is transmitted according to the same laws as physical peculiarities.

There are other diseases inherited in an entirely different way. I will commence with microbe diseases. In these diseases the affliction which has stricken either the father or mother, or both, is transmitted to the child through an entirely different process. It is really contagion. In certain diseases the mother, carrying some deadly germ (which she may or may not have received from the father of the child), contaminates her child before its birth. That is most usually the case on the average. I do not insist upon it. These cases are known as "heredity contagion." Oftener still, the child is born safe and sound, and it is only during the course of the first months or the first few years that it is contaminated by one or the other of its parents. It is apparent that it does not seem to be more than pure heredity. Tuberculosis is like that. You know how tuberculosis appears to be inherited. In your Red Cross dispensaries you find that entire families are now and then decimated by tuberculosis; the father or mother, or both, are ill with pulmonary tuberculosis; the new-born children die of tuberculosis meningitis; if they escape that, they show signs toward the fifth, tenth, or twelfth year of "King's evil," or tuberculosis of the glands; of Pott's disease, osteotic tuberculosis of the vertebræ; of coxalgia, arthritic tuberculosis of the hip, etc.; and at last, during their youth, they succumb to pulmonary tuberculosis. Such facts are unfortunately reported each day, and we understand how belief in the inheritance of tuberculosis has permeated the mind. In reality heredity here plays only a restricted rôle, as I will show you. The great secret in its spread is contagion. A proof of it is that the disease is communicated just as easily to persons who live with a tuberculosis family, though they have no relation to it. Sometimes it is neither the father nor the mother who is the source of disease which has stricken their children successively, but it may be a governess or a domestic affected with tuberculosis. I once knew of a family free from tuberculosis where a young widow returned to her father's home after having been married a year to a tuberculosis husband, from whom she had caught the germ of the disease; she communicated it to her two young brothers, who died, and then to her mother, who at present alone survives her three children. One could relate innumerable instances of this kind. I do not wish to say that heredity has nothing to do with tuberculosis. It influences more or less a resistance to the disease. In some families we

see certain forms of tuberculosis galloping from the start with such rapid strides that no treatment can check them. Repeated contamination, colonies of bacilli that have crept in, certainly may be the cause of it, yet it is believed that there exist some soils favorable through heredity to the growth and spread of the bacilli. But if children of tuberculous parents are protected as much as possible from infection of the bacilli, we have found that the disease has not developed in them. My teacher, Grancher, believed this, and with that idea he founded the " Oeuvre " for the protection of children against tuberculosis. That foundation takes children from homes where the sick father or mother by coughing is spreading the bacilli; it raises these children in peasant's homes in chosen localities in the country. It is demonstrated that these children show a much smaller proportion of tuberculosis than the population taken as a whole.

In short, in the propagation of microbe diseases in families, heredity, properly speaking, plays but a very limited rôle. The propagation of disease is due to contagion, heredity contagion for certain diseases, but, more often still, common contagion, and this rule applies particularly to tuberculosis.

I have to speak to you now of another deduction where the diseases of parents may affect the condition of the child. When the parents at the time of procreation are in a bad state of health they give birth to children who have what has been called " the defects or scars of degeneracy." This is not really inherited, for it shows no resemblance between parents and children. On the contrary, the children in these cases have strayed from the type of people to which their parents belong; they develop abnormal characters, which show that they are different from the usual conformation of their race and species, and even that of the normal human being. This is the literal significance of the word " degeneracy."

It is degeneracy, for example, which is seen in descendants of drunkards. The question is really not one of heredity, but of precocious intoxication from a germ or, to state it better, from sexual cells which are developed in a manner modified in their normal composition by alcoholic impregnation. All kinds of intoxication act the same—intoxication from opium or morphine, the professional intoxication from tobacco (from workmen in tobacco manufactories), or from lead (workmen employed in the making of red or white lead). A proof that intoxication from the germ is the cause of it rather than heredity is that intoxications in youth show the same result. Early alcoholism develops vices analogous to those due to alcoholism in the parents; chronic microbe diseases succeed, like intoxication, in seriously affecting the internal life. Syphilis in the parents (even when it has ceased to be contagious, which seems to prove that the microbe is no longer the cause of it) may also produce " degene-

rate scars" upon the infants, and likewise cause serious infections of youth, chronic gastroenteritis, "athrepsia," etc.

These facts show us that heredity only preserves its power when the infant possesses normal conditions for its development identical to those that their parents had. Otherwise the child ceases to resemble them; he is degenerate. This is opposed to inherited transmission.

This distinction is important, and it becomes much more important to dwell upon it since able authors do not appear to have found it out. I have spoken to you of the excellent and very interesting work of Mons. Galippi. Everything is perfect about it save the title. Mons. Galippi has called it "Hérédite des stigmates de dégénérescence et les Familles souveraines" (Heredity of the stigmas of degeneracy and the royal families). Now he shows us a certain conformation of the face transmitted by heredity, a similarity to one another through many generations of the same line. It is the transmission of a family characteristic; it is directly opposite to that which transpires from the "stigmas of degeneracy." These stigmas momentarily separate some descendant from the normal family type. If the distributing influence which has deviated these subjects from the normal type ceases to act, their descendants return to the normal type. We have seen this in certain groups of peoples subjected to defective hygienic conditions; thus the malarial regions of the Bresse, the Dombes, and the Landes were inhabited, before the sanitary improvements were made, by a small-sized race, many of whom had various malformations described under the name of stigmas of degeneracy (the registers for army service at the time show this). From the time when these countries were made healthy by draining the swamps, the new generations became of normal size and now there are no more exemptions from military service for constitutional defect in those cantons than in those places which have never been touched by malaria. These facts are strictly analogous to a very great degree to those seen in certain animal or vegetable species. There exists (I mention this example among a thousand others) a species of crow-foot which, when the seed sprouts in submerged land, has lacinated leaves altogether different from the ordinary leaves of the plant when grown in dry soil. If made to grow in submerged land for a number of successive generations as long as the experiment permits, and if the seeds are gathered at each generation, those seeds which were sowed in dry land would surely produce full leaves without the number from the lacinated generations having any influence. The lacinated state, then, is a condition of degeneracy which exists only when a cause provoking it exists. Heredity plays no part in its propagation. It is important to distinguish these facts from facts of heredity or they will become complicated.

This is one of the reasons why the observance of traits from heredity is so difficult. They are complicated by the intervening of such numerous disturbing elements that the laws of heredity can be established only by experimenting on some cases simplified as much as possible. That is what Mendel has done. Before showing you the very simple and suggestive laws discovered by Mendel, I ought to tell you in a word the work of the investigators who preceded him.

Naturally, I can give you only a brief and necessarily incomplete sketch of this history.

About the middle of the last century there were many students engaged in researches on heredity. Lucas published (1850) a book entitled "De l'hérédite" (On Heredity), in which he showed that the condition of the descendant results from the combination of two factors: (1) "Heredity," which brings about a resemblance between the subject and its parents and ancestors; (2) "innéite" (inherent), causing a dissimilarity. Thanks to the innate idea, we see in some families certain members who show no characteristic peculiar to the family. We now know that that theory is based on some deceitful appearances explicable by disturbing causes of which I have given you an example. The doctrine of Lucas has been forgotten by savants for a long time. If I have spoken to you about it, it is as a contemporaneous writer. Emile Zola has based upon it that great work of the Rougon-Macquart; he has sought thus to give it a scientific foundation; the unfortunate part is that before Zola had even commenced the publication of the first volume of that set of books other authoritative articles had already brought out the weak and inaccurate points of Lucas's theory.

A great English investigator, Sir Francis Galton, has employed, like Lucas, the direct method of observation in the study of acts of heredity. He has carried it to a very high degree of perfection. Thanks to some devoted cooperators, he has united a large number of genealogical trees in noting the physical, intellectual, and moral characteristics of all members in the family studied. A periodical work, "Biometrika," published these articles. The results were worked out in a special laboratory which is perpetuated under the name of the Sir Francis Galton Eugenic Laboratory. In applying to results thus accumulated the process of higher mathematics, Sir Galton and his pupils have established an empiric law, the formula of which, however, has changed. At first Galton showed that the two ancestors of the first generation (father and mother) control one-half in the heredity of a subject, each one being a quarter; then the four ancestors of the second generation (grandparents) are valued at a quarter in this heredity, one-sixth for each one; then the eight ancestors of the third generation (great-grandparents) come in for an eighth or a sixty-fourth for each one, etc. Subsequently,

Pearson, a pupil of Galton, saw that to agree with the reality, that formula was exact and conformed to observations only if there was made to intervene in each generation a corrective coefficient varying from the rest according to the subjects and characters considered, the corrective corresponding in total to the "innéite" of Lucas. On the whole, the "biometric method" of Galton and Pearson, in spite of the magnitude of their effort, led to such complicated formulas that they were unprofitable in practice. Besides, they gave simply formulas of a general term not at all applicable to a particular case considered independently of all other cases.

We are about to see that the formula of Mendel, which is much more simple, explains the results empirically stated by Galton and Pearson. The formulas of these last explain the proportion from the results given by the laws of Mendel applied to the whole of an extended population.

Mendel's laws are the foundation of the study of heredity to-day. But we should not forget that the most important of these laws had already been discovered by our compatriot, Naudin. Naudin, about the middle of the last century, had undertaken the study of the phenomena of hybridization, as Mendel had done, and had discovered the phenomenal principles which a little later attracted Mendel's attention, particularly the resemblance of some hybrids to one of its parents and the disassociation of characters in the descent. Naudin, who was deaf, and therefore isolated by his infirmity, did not know how to make the most of what his works merited, and it is to Mendel that the glory of establishing the remarkable laws which deservedly bear his name is given.

The fame of Mendel is of quite recent date; it has only been a few years that the learned world has known his name; and now it is already famous enough to have societies named for it ("Mendel societies") and a periodical (Mendel Journal) devoted exclusively to drawing from the discoveries of Mendel the inferences which they bear. This glory is tardy. It was in 1868 that Mendel published his discovery, but it was ignored, and it was not until 1900 that the Dutch naturalist de Vries brought out Mendel's laws, and it was not until then that the name of Mendel commenced to spread abroad.

Mendel was a monk in a convent of Moravia near Brünn. In his leisure hours he devoted himself to the study of natural history and cultivated a little garden where he hybridized sweet peas; it was in this way that he discovered the laws of hybridization which he published in a small local scientific paper, called "Bulletin de la Reunion Scientifique de Brünn," and they remained buried there. After a time, Mendel was appointed superior of the convent; his new occupations prevented him from continuing his work, and he died without knowledge of the fame which awaited him.

Mendel noticed the fact that when two varieties of plants differing in one characteristic only are crossed, the red or the white color of the flower, for example, all the seeds obtained therefrom produce in the first generation plants having red flowers only; if these hybrid red plants are crossed with them, 75 to 100 per cent of red-flowered plants and 25 to 100 per cent of plants with white flowers will be obtained. If the stalks of the white flowers are afterwards united, the red color would never appear; the stalks of the white flowers reappeared in definite proportions in the descent from the stems of the red flower united between them.

Mendel thought that the two characteristics, red coloring and white coloring, both exist in the hybrids of the first generation, but the red characteristic dominates the white and appears only when they exist side by side. If we call "R" the red characteristic and "B" the white characteristic, the formula for these hybrids is R(B), the parenthesis denoting that (B) is latent, because it is dominated. If a plant R(B) should be crossed with another plant R(B), the two characteristics would disassociate themselves in the pollen grains and in the ovules; half of the pollen grains contain only R and a half contain only B; the same with the ovules; the 50 per cent of pollen grains R now unite half with ovules R, half with ovules B; the fertilized ovules which result from the union have now as a formula half RR, or 25 per cent and half R(B), or again 25 per cent. In the same way the 50 per cent of pollen grains B unite half with ovules R and half with ovules B, and the fertilized ovules which result from this have for a formula the half R(B) and half BB, or 25 per cent R(B) and 25 per cent BB. The total is 25 RR, 50 R(B), and 25 BB. But the R(B) are red like the RR and can not be distinguished from them. There are now 75 per cent of red. Unite them and the reds still give a certain proportion of whites, which can be calculated for each generation under the formulas of the law of probabilities. Without entering into the detail of these formulas, understand that at the end of n generations of unions between reds resulting from the first crossing, the white being at each generation separated from the reproduction, we obtain n^2-1 stalks of red flowers for one stalk of white flowers. On the contrary, it is well understood that the stalks of white flowers BB united with each other never produce anything but the stalks of white flowers; they do not contain, either obviously or in any unseen way, any red element.

Such is Mendel's law. It is applicable not alone to the colors of plants, but to all other living beings, animals, and vegetables, to all simple characters, capable of producing two and two in varieties differing only by single characters. This law is found in the union of gray mice (dominant) with white mice (dominated), of normal

mice (dominant) with dancing mice (dominated), in the union of bay horses (dominating) and sorrel horses (dominated), in the union of a single-comb hen (dominating) with a double-comb hen (dominated), etc., and finally in the human species. In the human species verification of these laws can not, you understand, be carried so far. Nevertheless, it seems to be an established fact that light hair and blue eyes are dominated characters in the Mendel sense opposing the black hair and eyes, which are dominating characters; and one can, from that statement, infer from heredity the color of hair and eyes, some conclusions which are being verified almost constantly. In the same manner human albinos comport themselves the same as the white albino mice, and in their union their descendants obey the same laws. It is the same with many morphological peculiarities, which conduct themselves some after the manner of dominating characters and others after the manner of dominated characters. In family diseases the morbid character is inherited in certain diseases after the manner of dominating characteristics and in other diseases after the manner of dominated characters. In a word, Mendel's law is very general, from the highest to the lowest forms of life; it applies to a number of characters of varieties that may proceed from morphological, physiological, or pathological characters.

The discoveries of embryologists have made known how the mechanism of impregnation explains the Mendel law. By the combination of embryological discoveries and Mendel's discoveries we can state that the mystery of heredity has now ceased to be a mystery; nature has raised for us a new fold of her veil.

You know that all living beings are formed from the aggregation of very numerous small living elements called cells. Each cell is composed of a tiny mass of living matter, the protoplasm, in the center of a more highly organized part, the "noyau." All living beings sprang primitively from a single cell, egg, or ovule. The simplest of living beings remain all their lives formed of a single cell and reproduce themselves by simple division into two, from the cellular nucleus at first, and from the protoplasm mass later. Heredity among these lower forms of life is explained very naturally, since the two new beings are only, so to speak, a continuation of the primitive being.

With beings a little more complicated, the cellular egg undergoes successive divisions and produces a great number of cells, which remain agglomerate, and the ensemble reproduces the morphology peculiar to each species. A certain number of cells from the interior of the body are alone susceptible of giving birth to new beings; they constitute the eggs of the animal or the ovules of the vegetable. Although other cells are differentiated, these reproductive cells have

remained identical to the primitive reproducing cell, the successive divisions of which have led to the formation of the being in question. Here, again, the explanation of heredity is not difficult. The new reproductive cell is identical to the primitive cell. It is very natural that its evolution should be identical to that of the last, on one condition, however, that it finds, for its life and development, conditions identical to those which the primitive cell found. Now, these conditions exist for inferior beings; they live in the dense ocean, which has a composition very nearly stable. If, however, the conditions of development are artificially made to vary, either the embryo dies, which is the most frequent contingency, or descendants are obtained which differ from the parents by their irregularities, veritable stigmas of degeneracy (analogous to those of the descendants of human beings, the physicochemical composition of whose internal organs, of the blood, has been changed by sickness or intoxication, as the children of diseased or alcoholic parents, for example).

Upon the whole, heredity is easily explained, as well as deviation of heredity, as long as reproduction is a question of nonsexual beings, which inherit their characters from a single parent, and not from two at a time—the father and the mother.

As to the sexual reproduction of beings, the embryologist also gives us some very satisfactory explanations which accord very nearly with those which observations give us as to the manner of heredity transmission, and places in a vivid light in particular the facts observed by Mendel and his successors.

For sexually reproduced beings (we will speak, if you wish, only of animals, but it is also the same with vegetable life) the egg—that is, the primitive cell, the successive division of which will form the new being—is constructed from the intimate fusion of two cells, one of paternal, the other of maternal, origin, each one supplied from a kernel. The particular point is the constitution of those sexual cells from the kernel. Their ripening (that is, the moment from which they are susceptible of blending with the cell from the opposite sex to form the egg by that fusion) is marked by a curious phenomenon. One half of their kernel is expelled; the kernel divides itself into two with no special method; one of the halves reaches the pole of the cell and forms what is called the polar globule; then it is expelled. Each sexual element represents then a half cell, at least where the kernel is concerned; but it is the seed which is important in hereditary transmission. Here is proof of it: The sexual feminine cell is very large, containing in certain cases a thousand times more protoplasms than the masculine cell, which is very small and reduced almost to a seed, or, rather, a half seed. However, paternal heredity is not less power-

ful than maternal heredity; the origin from protoplasm carries very little weight from the standpoint of heredity; what really matters is the origin of the seed.

Since the seed is formed from two half seeds blended together, that explains how it bears in it two hereditary characters at the same time, as Mendel has shown. The Mendel formulas RR, RB, BB are, then, in exact accord with that which the microscope reveals to us of the embryological mechanism.

In showing you the Mendel laws we have supposed a simple case in which the parents differ only in a single character, the coloration, "R," and the albinism, "B." In reality there are a very great number of characters that make up the noyau, and each one is double in each cell, as much from the father as from the mother. In the cells from the father each double character is formed of an element proceeding from the paternal grandfather and of an element proceeding from the paternal grandmother, one of the two being latent. Then, from the expulsion of the polar globule one of the two elements of each character is expelled, and the expulsion bears by chance on the elements coming from the paternal grandfather on the elements coming from the paternal grandmother. The same happens in the mother's cells. Finally the cellular egg permits of a very great number of juxtaposition characters. The half comes from the father, half from the mother, and half between them are latent. But the proportions due to each of the grandparents are not fixed; they are given up to chance by the expulsion of the polar globule, and it is only when one considers the average results on a great number of subjects that the chances in an inverse sense balance each other and you arrive at the law of Galton; that is to say, one-sixteenth coming from each grandparent, one-sixty-fourth coming from each great-grandfather, etc. One can compare the juxtaposition in the descendant of the characters of paternal and maternal origin to a double mosaic, each one formed from little blocks of marble, added two by two; that which is under the corresponding block is the latent character, the other is the dominant character species.

In the same animal species the design of the mosaic remains always the same, but the matter of which each block is composed varies according to the individual. Two brothers resemble each other, because the blocks selected to compose their mosaic are taken from the two identical sources; but they resemble each other incompletely because the chance which provides for the distribution of the blocks proceeding from the grandparents and for the elimination of half of each gives changeable results; the half of the blocks are eliminated, and it is not always the same ones which are eliminated. It is, however, a case where the resemblance between the two brothers is strik-

ing. It is the case of twin brothers called "univitellins." There are twins called "bivitellins," who owe their origin to the development of two eggs side by side; these do not resemble each other more than two ordinary brothers. But there are also twins called "univitellins," who owe their origin to the fact that a single egg is primitively cut in two and each half has developed a complete being. Then the identity is complete, and there is no more striking demonstration of the power of heredity than to see these two beings, who are sometimes brought up under different conditions, who choose different careers, and who, nevertheless, resemble each other so closely that their families are apt to confound one with the other even up to extreme old age. In these cases the mosaic is not only made on the same design (as is the case with all beings of the same species), it is not only formed from blocks taken at random, one half each from two different sets and distributed at random, in two different stages, but it is the same choice—I should say the same expulsion of the polar globule—which has presided at the distribution of the blocks. It is, as it were, a perfect replica of the same mosaic. You see, ladies, how the knowledge of these laws and the mechanism of heredity explains certain facts up to this time considered as unaccountable curiosities.

It is not alone in the interest of curiosity to understand the laws of heredity. I have told you that certain diseases—family diseases—are obedient to these laws in their transmission; that the physical, intellectual, and moral faculties are inherited in the same way. The knowledge of these laws permits the avoidance of certain dangers that could result from certain unions. Up to the present time doctors are contented with dissuading in a general and vague way from a union with families where one of its members might have shown a physical, psychical, or pathological defect (but what family is entirely exempt from it), and to proscribe all consanguineous unions. Henceforth the prohibitions should be more precise and more clearly stated, and, on the other hand, permits which would have terrified the ancients should be given without any hesitation. Studies of this kind are but just beginning. Some influential societies have been formed in other countries for the study of this subject; in England and the United States they have become of great importance. In France La Société Française d'Eugénique was very recently organized. The results already obtained from these efforts are most encouraging.

In closing this lecture I wish to call special attention to certain conclusions of practical importance.

First. In microbic diseases, and especially in tuberculosis, heredity is far from being fatal. One can hardly say that children of tuberculous parents inherit from a soil favorable to the development

of the bacillus. If care be taken to avoid contact with persons who are suffering from the disease, they will have a good chance to escape the terrible scourge.

Second. Aside from the diseases from microbes, there are other disorders, notably hereditary, known as family diseases. And here, also, up to a certain point, the perpetuation of the disease may be avoided by binding oneself to certain strict rules. Each of these diseases has its own method of hereditary propagation, and knowledge of this method indicates the unions which the laws of heredity prohibit.

Third. Physical, intellectual, and moral faculties are likewise inherited under the same well-defined laws. But they are not fixed in the descent, as when their heredity is bilateral.

Fourth. Great efforts are being made at this time to perfect and extend the studies relating to heredity; societies and eugenic laboratories are being founded. We can hope that these efforts will show us the way to secure amelioration for the generations to come, and a lessening of congenital defects, the frequency of which weighs so heavily upon poor humanity.

The Use of the Pedals. This brings us to the use of the pedals. To a passage of this sort we may apply what is called the "syncopated" pedal. The general rule as to pedalling with the damper pedal (the right foot pedal) is that we may depress it, and keep it depressed, as long as the harmony of a passage does not change. When the harmony changes we must lift the foot and release the pedal, instantly re-depressing it if we wish a continuous pedal effect. For detached chords the pedal may be depressed at the same moment as the keys, but in the course of a legato passage the finger and foot must not go down simultaneously. On the contrary, the pedal must rise just as the next keys are being depressed, immediately going down again, however, to continue the new sounds. This "syncopated" pedalling *joins* the sounds without allowing them to overlap. If foot and finger rose *together* there would be a short silence between the sounds.

This syncopated pedalling may be applied to every note of a melody or every chord of a harmonic progression, such as the above-mentioned Chopin chorale. Such constant pedalling in great portions of modern music is absolutely essential, but we must not lose sight of the great importance of *omitting* the pedal at other times. Many players of to-day over-pedal, thus losing the advantage to be gained by the contrast between pedalling and its total cessation. Chopin without the damper pedal would be like a Whistler picture reproduced in the style of Sir Noel Paton. Schumann was a still greater devotee at the shrine of the damper pedal; he did not care about harmonic exclusiveness, he liked to put down the pedal and to keep the course of harmonic changes in unbroken legato—too much so very often, in fact, and the pedalling marks in many of his works require much revision. Chopin was much more refined in his use of the pedal, probably because he was a better pianist. Mendelssohn was ultra-refined, and we must bear this in mind in playing h[illegible] music; let his outlines be definite, his colours [illegible] rhythms free from emotional exuber[illegible] [illegible]articularly to be "good," as he [illegible] puts it, and refrain even from a self-indulgent rallentando at the end of a composition.

Use of the "Una Corda" Pedal. The "una corda" pedal should be used sparingly. Modern composers, as a rule, indicate the use of it, as, for instance, Grieg in his well-known Lyric pieces. Very frequently it is used in combination with the damper pedal; the two are quite independent. Use both pedals very sparingly, if at all, in performing the music of Scarlatti, Couperin, or Bach. The first two composed for the harpsichord, and even Bach's clavichord, although it did possess some sensitiveness of touch, was not much like a modern piano.

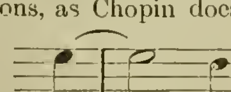
Part Playing. Much modern pianoforte music consists of a melody with accompaniment. We must listen to the *end* of each melody note as much as to its beginning, in order that we may join it perfectly to the following melody note, and that we may choose the right tone for this succeeding note. To bring out the melody also, we must be careful to *su[illegible] very much the accompaniment*, and not let our attention to the *phrasing* of the *melody* be distracted by the accompaniment. If the melody be at the thumb side of the [illegible] as in Schumann's beautiful Romance [illegible] and in many popular waltzes, remem[illegible] use of the rotary relaxation there; if [illegible] little finger side, as more frequently [illegible] we must see to it that the forearm [illegible] relaxation helps the weak fingers at that [illegible] Have a melodic ideal ever present—im[illegible] such melodies given out by the 'cello, the [illegible] or the voice, and imitate these. When a no[illegible] sustained while other notes play round [illegible] *listen to the sustained note to the end.*

It is not enough merely to keep th[illegible] down; we must connect the sustain[illegible] intelligently with that which follows [illegible] own part. Practise Bach for such part [illegible] the playing of several melodies one above the other—his melodies are more difficult to [illegible] and more difficult to connect subtly th[illegible] Chopin's—and listen to all the interwoven pa[illegible]

Crescendo and Diminuendo. A [illegible] fect crescendo or diminuendo, especially [illegible] sustained, is seldom heard, and yet they are among the most entrancing and convincing of musical effects.

The crescendo in performance w[illegible] introduced till late in the eighteenth [illegible] in the orchestra at Mannheim; and when t[illegible] audience first heard this new effect, [illegible] said they rose from their seats like one man. Real[illegible] the emotional possibilities of *nuan[illegible]* [illegible] The secret of getting a good cres[illegible] is, as Von Bülow, the cleverest and wittiest [illegible] teenth century pianists, puts it, "wh[illegible] see the expression mark 'cres.' play softly, when you see the mark 'dim.' play loudly." This gives us something to work away from, and prevents our making the common mistake of *at once* playing louder at the beginning of a crescendo, $<$, or softer [illegible] beginning of a diminuendo, $>$

The same thing holds of acce[illegible] [illegible] and retardations of time. Accelerando must be gradual and continued, as mu[illegible] [illegible]rdando. It is different in the case of ritenu[illegible] which is a *sudden* slackening of the tempo [illegible] requires all our attention to keep an accelerando really accelerating to its climax, and [illegible]itardando really slackening note by note till [illegible] animation dies out; "and we must remember," says Mr. Matthay, "that all such effects, both of tune and time, must increase with an increasing *ratio* to be effective." Reference must be made here to time accents, a most effective means of expression. Composers use them in the form of syncopations, as Chopin does in his waltzes:



Time Accents. In performances we can make a melody note *seem* accented by making

it either slightly longer than is due or letting it begin just a very little too late. We may also delay a little the entry of the accompaniment *after* a melody note which we wish to make specially prominent, and then, by hurrying the time a very little, make up for this irregularity. This is the principle of the tempo rubato, which even Mozart employed in a measure, as we learn from his letters, and which must be applied to all modern music since the time of Chopin and Liszt. These two pianist composers were the great protagonists of the tempo rubato, or robbed time.

Although seemingly whimsical and wayward, it is really rooted in a strong sense of rhythmical balance, and Liszt compared it to a tree firmly rooted in the soil, whose branches were yet played upon by the wind. Only those who are anchored to a perfect feeling for rhythmical balance and symmetry can safely trust themselves to the waves of tempo rubato. It takes effect in prolonging some notes, hurrying others, dragging one part of a phrase, accellerating another, either dragging or accellerating a series of phrases and making up for it with the remainder of the period ; but, whatever form it takes, it should always be so perfectly balanced that the period ends where the strict metronome beat *would have had it end* had the time never been bent from the straight line. Without the tempo rubato, the music of Chopin would be vulgarised, and much of Schumann rendered unintelligible ; but we must beware of applying it to any extent to the earlier composers, as Haydn or Schubert—it would destroy the meaning and symmetry of their music.

Ornamental Notes. It is a mistake to hur[illegible]dering of ornaments—in cantabile [illegible]ould see that we *sing* them. Let [illegible] notes in very truth, and let them [illegible] the particular beauty, and [illegible]pecial character, of the music th[illegible]

[illegible], light ornaments should be played with as little weight as possible, remembering that such are in truth agility passages of short duration, and that the touch laws for agility must therefore be obeyed in them. Do not (as so many are apt to do) lift away the weight of the hand in preparing for this. Most delicate finger-work, other than pianoforte playing, requires, possibly, that the hand should support itself by its own muscles, and so, instinctively but wrongly, the inexperienced player prepares for a delicate passage by lifting away the weight of the hand. Such a proceeding is fatal to ease, certainty, and beauty of tone. As already pointed out, we must let the hand lie on the fingers, and see that it makes no exertion of any kind in such light passages. "Prepare" such a passage with as many fingers as possible, feel the resistance of keys, let the loose, light weight of the hand *lean* against the keyboard, then imagine the whole group as one concept—not conceiving each note singly—thinking only (if it be a long passage or cadenza) of the notes that form the landmarks of the passages and the fingers that fulfil these "landmark" notes, and leave all the rest to subconscious automaticity.

See that we breathe deeply, fully, freely before starting on one of these long embroideries, such as occur, for instance, in Chopin's Berceuse, and keep the whole body passively quiet meantime, as the least thing will disturb us in the execution of such fairy-like webs of sound. *Holding* the breath through difficulties and subtleties of this kind is a bad habit to fall into. See to it that we use either what Mr. Matthay calls "passing-on touch," or first species, or perhaps second species for the louder portions, and make sure of the preliminary and continuous resting. Let no excitement and nervous tension communicate itself to the up-muscles of the hand, and so cause it to become active to the extent of lifting away its own weight. Then, with a clear mental picture of what we want to produce, "the rest shall be added unto us." To ornaments, as to melodies, the tempo rubato may be applied ; shakes may be begun slowly, accelerated towards the middle, and slackened off again towards the end.

Beethoven's Influence on Technique. When sufficiently advanced, we should make not only Bach but Beethoven our daily bread. He will force us to give attention to the music, and to develop a varied tone-palette for its expression. We cannot lazily dream through a Beethoven sonata after having once mastered the art of touch-variety. He expects so much from us, and his expression is often so unexpected, that there is no moment during his music when we may cease to be acutely alert, alike musically and instrumentally. Judging the due amount and quality and time-place of every note from start to finish, and watching key-resistance to see that we realise it, we must get a fine loosely-left arm and well-braced finger and hand for his frequent sforzando staccato chords, and give them with a convincing, well-nourished tone, or sharp finger-action instead, as the case may require. We must learn to obey his characteristic crescendo followed by a sudden piano, and learn to change our technique as suddenly as *he* changes his mood, from the passionately virile to the passionately tender.

From the moment of reading out a Beethoven sonata we should try to "paint" it—that is, try to play it with the constantly changing touch-varieties required. We must not say, "I shall get the notes first and then see what they mean," but look for the meaning through the notes by obeying them in every particular from the first. We should not begin the serious study of Beethoven till we *can* proceed thus. Of course the bravura work—the difficult passages and presto movements—will require to be worked at out of focus, but try even when working at these to conceive their place in the finished scheme. Remember that we never can express all there is in such music unless we obey the laws of tone-production, but remember also that artistic reproduction is the art which conceals Art, which is the goal of all technical study.

M. KENNEDY-FRASER

The Construction and Equipment of Cotton Mills. Cleaning, Carding, and Other Processes in Spinning.

COTTON SPINNING

The standard type of cotton-spinning mill in this country is an edifice of four storeys, brick-built, with a generous window-space [1]. In order to minimise the vibration of machines, the construction is solid. Cotton being inflammable and spun in heated atmospheres, the mills are made fireproof, and their ceilings are fitted with water-sprinklers.

Equipment of Cotton Mills. The upper floors are supported by pillars, and constructed of steel and concrete, or arched brick and iron, covered by boards. The modern style of building is somewhat ornamental externally. The rooms are light, lofty, and of the full size of the floor. They are approached by stairways set in a built-out tower, and fitted with emergency exits in case of fire. The premises are under the close supervision of the factory inspectors, who supervise the ventilation, cleanliness, hours of labour, and the fencing of machines.

The spinning-mills are driven almost universally by steam, and the power is transmitted to the several floors by ropes from the engine to the main shafts. The plant is designed to spin cotton of a certain length of staple to a particular range of counts, and the quantity of machinery in each department is exactly proportionate to that in every other. Consequently there is very little idle machinery. The load upon the engine is a constant one from starting-time to stopping-time, and this fact in part explains the preference for steam over electricity for the driving of spinning-mills. Coal is relatively cheap in the districts in which cotton is spun, and there is little waste of the power generated at the boilers. Great importance is attached to steadiness in driving, economy of fuel, and freedom from breakdown; and the building of high-speed mill-engines is a special department of textile engineering. Ordinarily the engine is housed in an annexe to the main building, situated near one of the corners of the mill. The engine and the heavy machines used in preparing cotton for the spinning-mules occupy the ground floor, and the lighter machines are placed on the upper floors of the building.

Preliminary Treatment of Cotton. Raw cotton received from the docks is taken into the bale-room, either on the ground or the first floor. It arrives from America in bales pressed to a density of 24 to 30 lb. per cubic foot, and before anything else can be done it has to be opened out into a loose condition. This is the work of the bale-breaker machine, the first of the series of machines in the *blowing-room.* The cotton was formerly loosened by the use of spiked rollers, which served the purpose, but tended to snap some of the fibres. The machine principally employed, called the *hopper bale-breaker*, has a gentler action, and helps to clean the cotton as well as to open up the matted mass. The hopper is a sort of box, of which the floor is a travelling lattice apron moving horizontally. The cotton is borne forward on this lattice, and pressed against an ascending lattice furnished with strong teeth. These comb out the fibre, and carry it upward, and at the top of the incline the cotton is met by the spikes of a roller revolving in the contrary direction. These spikes further comb out the cotton, and throw any unopened pieces back into the hopper. After passing the spiked roller the opened cotton is stripped from the inclined lattice by a beater, and falls upon a grid. From the grid the cotton is conveyed either to mixing-bins, in which different cottons are mixed together, or to a *hopper feeder.*

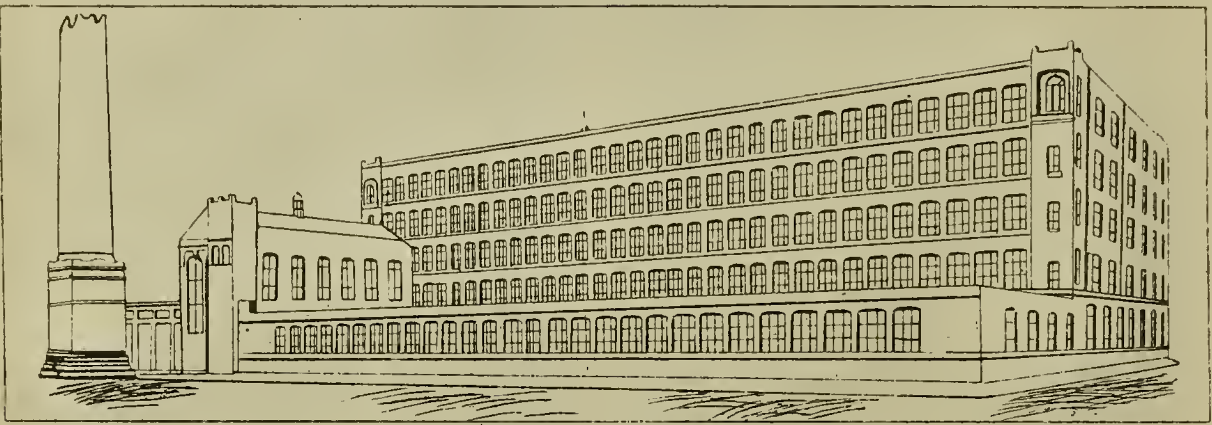
Cleaning Processes. In the feeder the cotton is similarly carried first onward and then upward by lattices and the comb-like teeth. There is a small auxiliary lattice to equalise the layer of cotton delivered from the machine, and in transit the material is beaten and loses some more of its impurities. After passing through the hopper feeder the cotton receives a further cleansing in the *lattice feeder*, in which it is conveyed to rollers which pull the fibre and present it to a swiftly rotating cylinder.

The quantity of cotton passing at one time is regulated at will, and it leaves the rollers, to be beaten severely against a grid, through which much of the sand, leaf, seed, and other impurity falls to the ground. By the action of large fans the cotton is then sucked along a tube, or *dust trunk*, passing over a ribbed lattice, which travels in the contrary direction, [illegible] itself on the way, and thus a further proportion of refuse is lost.

The amount of cleaning required varies with the original state of the cotton; and where dirty grades, like East Indian, are used, it is necessary to interpose extra machines, such as the *Crighton opener.* In the Crighton machine the essential parts are a powerful fan, a cage, and an upright shaft fitted with horizontal beaters. The action of the fan induces a partial vacuum in the cage, into which the cotton is drawn at the foot. Under continued suction the cotton rises in the cage, and is beaten successively by each row of blades until it escapes at the top, to pass on to a revolving cage, and thence to a lattice.

The succeeding machine is the *exhaust opener*, and it is fed from the delivery lattice of either of the machines last described. The cotton is caught up from the lattice by an air-current, and again beaten by the arms of a cylinder against the bars of a grid. It passes over wire-gauze cylinders from which the air is being

continually exhausted by the action of fans, and this suction draws out the remaining fine dust. After going through rollers, another beating and another suction-cleaning stage are undergone. At the delivery end of the machine the cotton passes through pressure rollers, and is finally wound off in a *lap*, or fleece.



1. DESIGN FOR A MODERN COTTON MILL

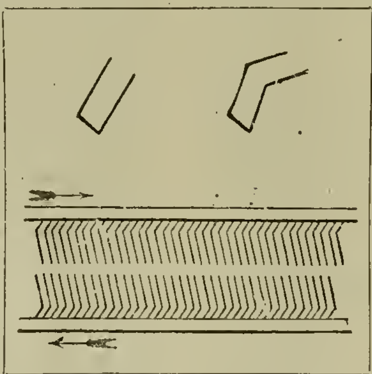
The production of this lap is the goal of the blowing department, and, when made, four laps from the exhaust opener are unrolled together and passed into the *scutcher*. In this machine the four are amalgamated into one, and after a final beating and suction the lap is ready for the *carding* department. The objective is the production of a perfectly even lap, having the same weight per yard throughout its length. In working the machines there are many points to observe. The speeds of the beating rollers have to be adjusted to suit the particular class of cotton. The grid bars require careful setting, and the regulators for controlling the machine require to be kept in good order. Although the series of operations looks a long one, the provision of lattices from machine to machine dispenses with handling the cotton and the whole operations require little labour, and occupy little room.

The Carding Engine. The purpose of the blowing-room is the production of a lap, and that of the card-room is the production of a sliver. While every operation depends on, and is controlled by, the operations that have gone before, that of carding cotton is especially critical, and it is impossible to produce good yarn unless the carding is well done. Despite the series of cleaning processes, the cotton is not absolutely free from foreign matter on entering the carding-engine, so one part of the work of this machine is to remove the remaining bits of seed and leaf.

It has also to remove *neps*, which are twisted curls or lumps of fibre, and to take out that proportion of fibre which is much shorter than the average. In the lap delivered from the scutcher the fibres run at all angles, and the carding-engine has to tease out these fibres into approximately parallel order. The work is much more delicate and exacting than the formation of a lap, and a mill may need 200 carding engines to cope with the laps made by five scutchers [3].

The principal element of the carding-engine [5] is the main carding-cylinder, of some 50 in. in diameter, clothed with wire teeth [2]. The teeth are inserted in a fabric or *fillet* of cloth or rubber, and are made of finely tempered wire. The teeth are bent at a uniform angle, and are sharpened by grinding to points of specified shape. Wires of different gauges are used, and fillets are made for different purposes, with numbers of points per square inch varying from 300 to 650.

The fillet is secured spirally upon the cylinder so as to cover its circumference uniformly and completely. Over the main cylinder is a lattice of cast-iron ribs, alsofurnished with card clothing, and forming an endless revolving apron. The ends of these *flats* are supported upon flexible, semi-circular rings resting upon fixed bends, which form part of the framework of the machine. The cylinder revolves quickly and the flats much more slowly. The distance between the teeth of the cylinder and the flats is capable of adjustments which are reckoned in thousandths of an inch, and between them these two sets of wires perform the critical carding operation.



2. CARD TEETH

Carding Operations. The lap from the scutcher is lifted on to a bracket in front of the machine, where it is unrolled. The end of the lap is gripped by a fluted feed-roller, and is delivered to a taker-in roller. The cotton passes over knives and grids designed to clear away foreign matter, and is swept on to the teeth of the main cylinder. The flats move in the same direction as the cylinder, and forty of them are always in contact. As their speed is slower than that of the cylinder, the fibre is combed out straight by their dragging action, and is carried forward to the *doffer*, a smaller cylinder, also wire-covered, and rotating at a lower rate of speed. The doffer completes the straightening of the fibre, and strips it away from the carding-cylinder. The doffer is in turn stripped by an oscillating comb, and a fleece of the full width

of the machine is brought away. The fleece, which is an exceedingly fine film, is forthwith condensed by guides until finally, in the form of a ribbon, or sliver, half an inch in diameter, it passes down a trumpet-shaped orifice, and is coiled in a cylindrical can.

The teeth of the flats are continuously cleared by a comb as they leave the main cylinder, and a grinding roller sharpens and levels the teeth of the flats continuously while carding is going on. Periodically during the day the *strips*, or short fibres, and the dust lodging between the teeth require removal, and every two or three months the cylinder and doffer have to be dismounted and re-ground. Several new forms of apparatus have been brought into the mill to avoid the creation of dust during the card-stripping and grinding operations. Home Office requirements grow in stringency, and require this dust to be dislodged without passing into the air of the room. There is a choice of appliances worked by fans and by vacuum pumps, and of smaller apparatus which confine the dust inside a cover.

The lap made in the scutching-room is of such a weight as to produce approximately the thickness of sliver required from the cards, but the desired perfection of uniformity is not arrived at in one operation. The *drawing-frame* [6] is relied on to smooth out inequalities and make a satisfactory sliver; and in making all but the finer qualities of yarn the material passes from the card to the drawing-machine. In spinning the finer numbers, however, it is necessary to eliminate the shorter fibres by a more drastic process than carding. The material is passed through *combing-machines*, preparatory to which the coiled sliver from the cards is put through *lap-machines*. The systems in vogue vary in some details, but agree in bringing from sixteen to twenty carded slivers together, passing them through drawing-rollers which pull out the sliver in lengths, and combine the whole in a lap of $7\frac{1}{2}$ to $10\frac{1}{2}$ inches wide, for the combing-machine.

3. A CARDING-ROOM AT HORROCKSES

Combing Machines. The combs in use are based on a principle which occurred to the inventor—Heilmann—as he watched his daughter nipping portions of her hair with one hand and combing the hair with the other. The prepared laps are supported on two corrugated rollers, and the slow rotation of these causes the ribbon of fibre to unwind.

The cotton first travels over a highly polished plate, which offers no friction, and then passes between feed-rollers, when it is fed intermittently and in lengths of about one-quarter of an inch at a time between nipping jaws. The jaws hold the ends of the fibres during the time in which rows of fine needles, set upon a small cylinder, push their way through the material. The rows are of graded fineness, the coarse needles entering first and the fine ones last, their work being to remove fibres so short that the ends are not held by the nippers. The combing-roller is furnished with needles over one part of its circumference only, the rest having a fluted surface; and as this fluting comes beneath the nipped cotton a small detaching roller—covered with leather—is lowered. This movable roller carries the combed cotton between two fixed rollers; and as they receive the addition they roll backwards and join the cotton previously combed to the material which has newly come forward.

Thus the machine is continually treating the fibres tuft by tuft, and adding the tufts together into a continuous length by overlapping them. While the newly combed is being added to that which has gone before, the nippers open and allow a new length to come forward. The half tuft behind the nipping jaws is combed by being drawn through the teeth of similar needles by the action of the detaching roller.

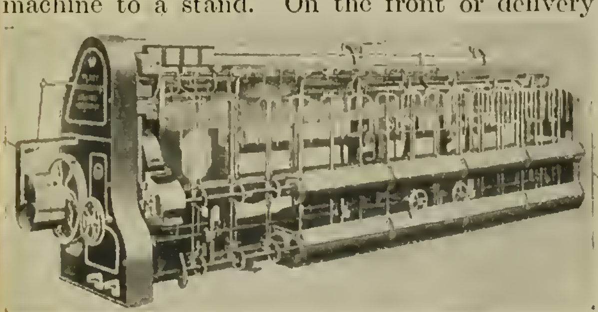
The short fibres removed from the lap are carried by the needles, from which they are removed by a brush, and the brush works in contact with a wire-covered doffer-roller, which

in turn is cleared by a doffer-comb. The waste is thus conducted to the back of the machine, and the combed sliver comes away in a web at the front. The ends of the sliver are led down to a bell-shaped orifice by rollers, and after passing through three pairs of drawing-rollers they are coiled inside cans.

The Heilmann comb is usually made to take eight or ten *heads* of slivers, and its parts are capable of the most beautiful adjustment. The Whitin comb is a modification of the Heilmann, and the Nasmith comb is regarded as the greatest improvement on the Heilmann machine that has been made. The Nasmith machine differs from the original in detail, and is capable of use upon fibre of a greater average length. Combed yarn is stronger than that which is only carded, and it is more lustrous. Yarns numbered 80s and upward are practically always combed, and it is necessary to choose combed yarn to get the best results in cotton that is to be mercerised.

The Work of the Drawing Frame. In returning to the *drawing-frame* [6] as the next in sequence in making carded yarn, it must be pointed out that its purpose is an equalising one. Its functions are to straighten the position of fibres one to another, mix the slivers from the different carding-engines thoroughly, and produce a sliver equal in all parts.

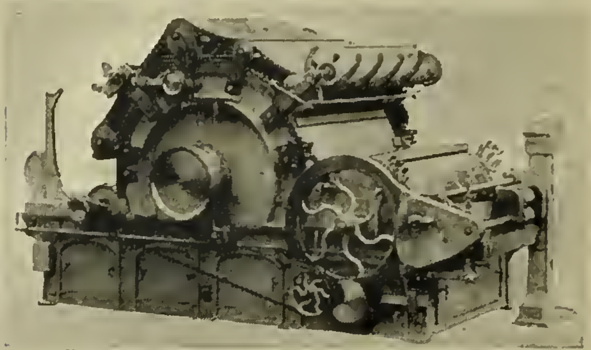
Coiled sliver is brought to the machine in cans, six or eight of which are placed together, and the contents of each are led into the machine. They pass through four or more pairs of top and bottom rollers geared at different speeds, the last rollers running faster than the first; and they thereby draft or draw the sliver finer and combine the whole into one. Varying with the counts to be spun, the material passes through the drawing-frame two, three, or four times over to secure a perfect amalgamation of the fibres. In order to avoid such trouble as would be caused by the unnoticed breakage of a sliver, the machine is fitted with stop-motions. In entering the frame each sliver passes over one of a series of *tumblers;* and the instant the drag upon this detector stops, the tumbler overbalances, and, by engaging with a rocking shaft, brings the machine to a stand. On the front or delivery



4. SLUBBING-FRAME

end another stop-motion comes into play, should the delivery cease or become too light in weight.

Twisting the Sliver. The sliver issuing from the drawing-frame is too coarse to be placed immediately upon the spinning-machine, and has to undergo a further course of stretching. As it is impossible to stretch a twistless rope far without pulling it in two, some twist has to be given to the sliver in order to allow further elongation to take place. Combined drawing and twisting is performed upon a further series of machines, and the finer the yarn that is being made the more machines have to be employed.



5. REVOLVING FLAT CARDING ENGINE

The pictures on this page are by courtesy of Messrs. Platt Bros. and Company.

Two machines serve for coarse yarns—the *slubbing-frame* [4] and the *roving-frame.* For yarns of medium fineness, slubbing, *intermediate,* and roving frames are needed. For the finest counts four frames are necessary—slubbing, intermediate, roving, and *fine roving.* Except that each successive machine has to deal with finer sliver than its predecessor, the machines are the same. They are *flyer* spinning-frames, adapted for heavy material and for imparting light twist.

The sliver comes to the slubbing-frame coiled in the can, and it is led over a guide through three pairs of drafting rollers. Leaving them, the sliver passes down the arm and through the eye of a flyer, and is twisted by the rotation of the flyer-spindle, and wound upon large bobbins, or tubes. The bobbins of slubbing are removed to the creel of the intermediate frame to be drawn and twisted a little more, and the bobbins from this frame are then lifted on to the roving-frame. On the roving-frame the procedure is the same, with the exception that usually two ends of the intermediate rove are drawn and twisted into one of roving. The fine roving-frame is requisitioned only for Egyptian and Sea Island cotton. Although the principle of each of these flyer-frames is alike, the sizes of the bobbins and flyers are not the same, and the speeds are very different. The slubbing-frame runs slowest and the roving-frame fastest.

Systems Employed in Cotton Spinning. The operations between the drawing and the roving frames are strictly in the nature of spinning, but the name of spinning-frame is reserved for the machine upon which single yarn of the desired fineness is produced. Two systems of spinning are used for cotton, both of which have been described broadly in the last chapter. They are, we may recall:

Ring-spinning, used chiefly for warp yarns in England, a form of spinning that requires little skilled labour, and can be carried on by girls.

Mule-spinning, which employs male labour, and can be used to produce yarns of every quality, and to employ any kind of cotton.

In the case of ring-frames it is impossible as yet to spin upon the bare spindle, although

inventors have made attempts to effect this improvement. The types of spindle in use vary in design, and differ principally in respect of the facilities for lubrication, a matter of importance in view of the high speeds at and long hours for which the machines run.

Type of Cotton	Production in Hanks per Spindle in 10 Hours upon Ring-frames	Mules
16s American	9·860	6·26
40s American	7·528	5·26
60s Egyptian	6·346	3·98
80s Egyptian	5·260	3·37

By comparison with mules the machines have few parts, and the production per spindle within a given time is materially larger. A comparison of the production in ten hours, taken from Messrs. Platt's tables, shows the differences given in the table on this page.

(= 336,000 yards per pound) can be spun almost without breakages. The mules for fine yarns are fitted with a *jacking* motion, which can be brought into play to secure an extra stretching, if desired, over and above that given by the ordinary outward run of the carriage. By use of this motion the drafting-rollers are stopped prematurely while the spindles are still working. Again, the fine mules are given a *double-speed* motion to accelerate the twisting in the case of very fine yarn.

The production from the mule machine is governed by the number of *draws*, or outward runs per minute of the carriage, and by the length of the *stretch*, which is shorter for fine yarns than for coarse ones. A mule spinning thick counts of 6s to 12s makes on the average over five and under six draws per minute. In spinning 60s to 80s yarn, the carriage runs out about three times a minute; in spinning 300s, the mule makes one stretch of 48 inches per minute.

6. SLIVERS PASSING THROUGH A DRAWING-FRAME

The amount of twist imparted, which is a controlling factor in the output of any kind of spinning-frame, is, it may be noted, approximately equal in each case.

Spinning-mules are known as Oldham or as Bolton mules, according to whether they are designed to spin the classes of cotton and counts of yarn generally produced in these towns. The *fine spinning* or Bolton mule is fitted with refinements not needed upon those for spinning medium counts, and so delicate is the arrangement of the finest mules that cotton up to 400s

A Triumph of Cotton Spinning. It will be seen that production at the rate of 48 inches per spindle per minute, the making of one pound of yarn 252,000 yards long is a slow process. The value of the product is, however, high, and worth commercially about 26s. per pound, or as much as thrown silk. The highest triumph of the cotton-spinning art, number 400s, measures about 190 miles to the pound, and is worth 90s. a pound, or about three times as much as the finest silk.

J. A. HUNTER

An Introduction to the Study of the Earth's Crust. How the Solid Crust was Formed.

THE MAKING OF THE EARTH

Geology, as its Greek name indicates, is "the science of the earth." It deals with the *structure* and the *history* of the planet on which we live, and with the *natural processes* which have moulded it. It endeavours to show how the world around us may have developed out of the gaseous *nebula*, or fiery haze of clashing atoms, which represents the earliest form in which the materials of the earth can be pictured by the scientific imagination. It teaches us to read the wonderful record which is written in the folds of the rocks and stamped upon the surface of the earth, and so to form an idea of the various stages through which our planet must have passed before it could be the fitting abode of human civilisation. Finally, it enables us to look with the eye of science below the smiling surface of fields and parks, or the sandy desolation of the desert, and to predict the places in which the miner, the railway engineer, and the well-sinker may begin their operations.

Geology an Open Air Study. The study of geology presupposes some knowledge of *geography*, or the superficial features of the earth, which it is the function of the geologist to explain and interpret. As a preliminary to his study, the student should read the chapter on the Solid Earth, beginning on page 287. It is further necessary to assume an elementary acquaintance with *chemistry* and *physics* when the student begins to inquire into the mineral constituents of the *earth's crust*. The student will obtain these from the special courses on the subjects.

The science of geology must be studied in the field and the quarry, no less than in the lecture-room and the museum, if it is really to tell a vital story. Indeed, the special charm of this science is that the best place to study it is in the open air, and that the most essential piece of apparatus for the scholar is a good pair of eyes and a strong pair of legs. The main *laws* of geology can be studied within the range of a holiday walk, though it may be necessary to travel far afield in order to witness their application on a larger scale. Here it is possible only to give an outline of the chief facts which are known with certainty about the materials of which the earth's crust is made, and the natural processes which have built them up into the fair and fertile earth on which we live. We endeavour, therefore, in this course of study, to set them forth much as an intelligent lad might be able to deduce them from a series of rambles with a practical geologist, saying as little as may be about those branches of the science which can be properly learnt only in a well-equipped laboratory and under the direct supervision of a teacher.

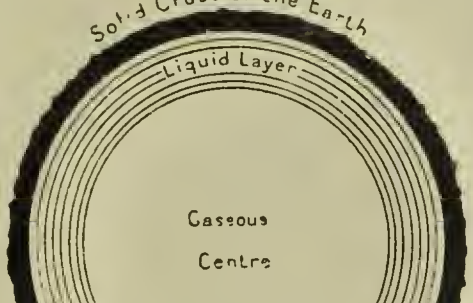
Subdivisions of Geology. The first thing which strikes the would-be geologist with open eyes, in the course of such a country ramble, is that the *features* of the earth's surface always differ, and yet are always recurring. Every turn in the road introduces a slightly different *landscape*, which, nevertheless, depends for its formation on a comparatively small number of details variously combined. The study of these details, with their unison in the several types of scenery, is the subject-matter of *Descriptive Geology;* the study of the natural processes which modify them is the subject-matter of *Physical Geology*, and the study of the changes through which they have come to exist in their present form is the subject-matter of *Historical Geology*. All the numerous subdivisions which learned inventors of names have suggested come under one or other of these main classes. We can, in short, study only the present and the past—what is and how it has come to be.

Geology deals chiefly with the *crust* of the earth, because it is the most important part of our planet—the part on which we live. It is also the only part which we really know. Man has done little more than scratch the surface; his deepest borings go down little more than a mile—one four-thousandth part of the distance to the centre. We can, indeed, infer a good deal as to what lies lower down, but we soon come to the intensely heated *interior*, as to the physical condition of which geologists are not yet quite agreed. It is almost solely the crust that we shall study, and chiefly that part of it which lies within a few feet of the surface. First, however, we must take a glance at the history of the earth as a whole. This belongs as much to *astronomy* (the course on which may be consulted for further details) as to geology, but some acquaintance with it is an essential preliminary.

The Earth as a Blaze of Light. The earth was once "a fluid haze of light." The whole *solar system*, in which it is one of the smaller *planets*, was originally a vast *nebula*, or swarm of fiery dust and gas molecules, roughly spherical, and more than 5000 million miles in diameter. This nebula was all rotating about its centre; it was also cooling, by the radiation of heat into space, and contracting. As it contracted it shed a series of rings at varying distances from the centre, each of which, with one exception, gradually coalesced into a planet revolving round the central portion, which formed the comparatively small star which we call the sun. The four outer rings gave birth to the major planets—Neptune, Uranus, Saturn, and Jupiter—which are still in a more or less nebulous condition. The next ring never coalesced, but broke up into a large number of

asteroids or minor planets. There were still four rings left behind as the nebula contracted, which formed the four inner and smaller planets—Mars, the Earth, Venus, and Mercury.

Our First Glimpse of Earth. Thus our first distinct glimpse of the earth shows it as a *nebulous star*, still intensely hot, and with no solid nucleus, rotating on its own axis, and at the same time revolving round the sun in a nearly circular orbit. The brilliant researches of the late Sir G. H. Darwin have illuminated this dawn of terrestrial history in a most curious and interesting fashion. The earth at present revolves on its axis in 24 hours—the artificial measure of time into which we divide the natural unit of the day fixed by the earth's rotational period. But it is steadily losing time. The tides, which are diurnally caused by the joint attraction of the sun and moon, sweeping round the earth in the direction opposite to that of its rotation, form a friction-brake precisely analogous to that which is used on the wheels of railway carriages or motor-cars. The retardation thus caused is so small as to be imperceptible in an ordinary lifetime; it amounts only to a lengthening of the day by about one-hundredth of a second in a century. But in the vast periods of geological time even a tiny change like this accumulates to a serious quantity. And when the earth was still plastic, or even liquid—as it must have been in the process of cooling down from its nebulous state—the tides produced by the sun and moon in its actual substance must have operated as a far more powerful brake. [See pages 424 and 1023.]



A SECTION THROUGH THE EARTH ACCORDING TO THE THEORY OF PROF. ARRHENIUS

Calculating this secular retardation backwards, Sir George Darwin showed that there must have been a time when the day was only two or three hours in length. The effect of tidal friction also operates on the *moon*, since, by Newton's Second Law of Motion, action and reaction are equal and opposite. The moon is constantly travelling away from the earth, and at the same time revolving more slowly. Working this problem also backwards, Sir George Darwin was able to show that there must have been a time when the earth was rotating in a period of between two and three hours, and the moon was revolving round it at the same period, at a distance almost inappreciable.

The Origin of the Moon. Another step in this luminous research was to show that when the earth was a liquid spheroid, rotating rapidly about its axis, it must have been in a state of dangerously *unstable equilibrium*. We do not know the exact speed with which it began to rotate after the nebular ring had coalesced, but we do know that at first, under the influence of solar gravitation, that speed must have tended to increase. Thus the liquid globe of the earth was exposed to two contending forces—that of gravity, which held it together, and that of the so-called centrifugal force, which tended to make it break up, as a grindstone or a fly-wheel bursts when spun too fast. It can be shown that when the period of the earth's rotation had decreased to about two hours and twenty minutes, these two forces were exactly balanced. The least increase in speed would overcome the force of gravity, which, of course, remained constant, and something must give way.

"The Moon Flung off from the Earth." It cannot be a mere coincidence that the calculation of the moon's motion, when it was all but in contact with the earth, shows that it must have made a complete revolution in something between two and two and a half hours. The conclusion is irresistible. Originally the moon formed an integral portion of the earth. [See page 1021.] But as the speed of the earth's rotation increased under the gravitational pull of the sun, it crept up to the critical velocity at which the earth could no longer hold together. There was a vast cataclysm, beyond anything which we can imagine, and the moon was flung off from the spinning earth—possibly in the form at first of a meteoric ring, which eventually condensed into our satellite. As soon as the moon had an independent existence, it set up vast tides in its parent earth, which acted as a powerful brake. The earth's rotation began to slow down again, and the moon began to travel outward in a widening spiral. This beautiful theory of the moon's evolution is now generally accepted. Thus we can read the history of the first, and still the greatest, geological cataclysm of which there remains any record.

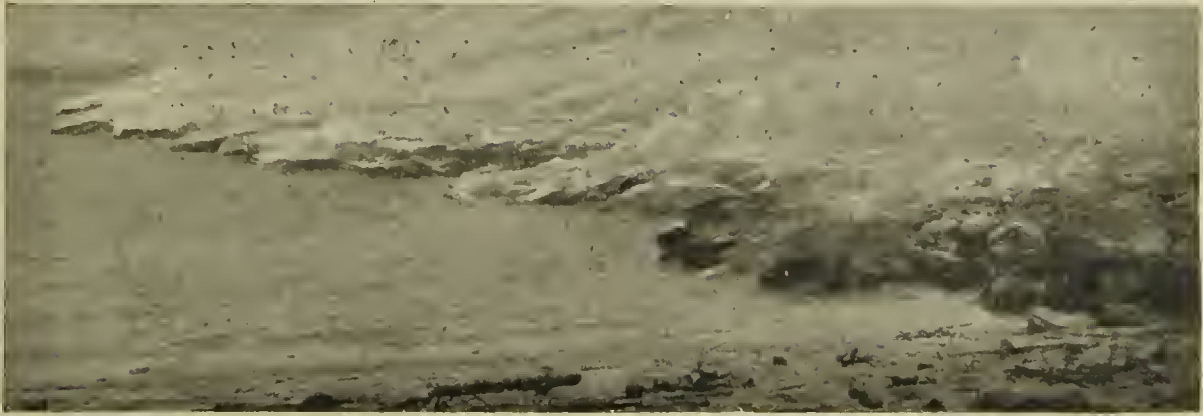
The Earth and its Envelopes. The earth, as we know it, is an *oblate spheroid* [see page 6]. The cause of this departure from the perfectly spherical form—which would have been assumed by the earth if its materials had coalesced under the sole influence of gravity and cohesion—is the earth's rotation combined with the solar tide. Calculation shows that the present shape of the earth is that which would have been assumed by a liquid globe rotating at its present speed, whence we conclude that the earth solidified at a time when its rotational period was practically the same as it is today.

The earth consists of shells, like an onion. It is a globe covered by a solid crust—the *lithosphere*—which is surrounded by an envelope of air—the *atmosphere*—and in part by an envelope of water—the *hydrosphere*. It is the lithosphere, and especially the crust by which it is bounded, with which geology is mainly concerned. The outer envelopes are chiefly

EARTH'S INTERNAL FIRES BURST FORTH

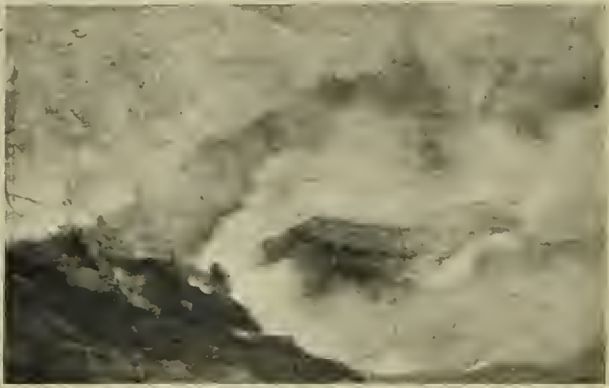
A DISTANT VIEW OF MATAVANU, A VOLCANO IN THE PACIFIC ISLAND OF SAVAII

SWEEPING DOWN TO MEET CALM OCEAN



STEAMING LAVA RUSHING INTO THE SEA FROM THE VOLCANO OF MATAVANU

INSIDE THE SMOKING CRATER OF VESUVIUS



THE SMOKING CRATER OF VULCANO

SMOKE AND FIRE POURING FROM THE VOLCANO OF MATAVANU

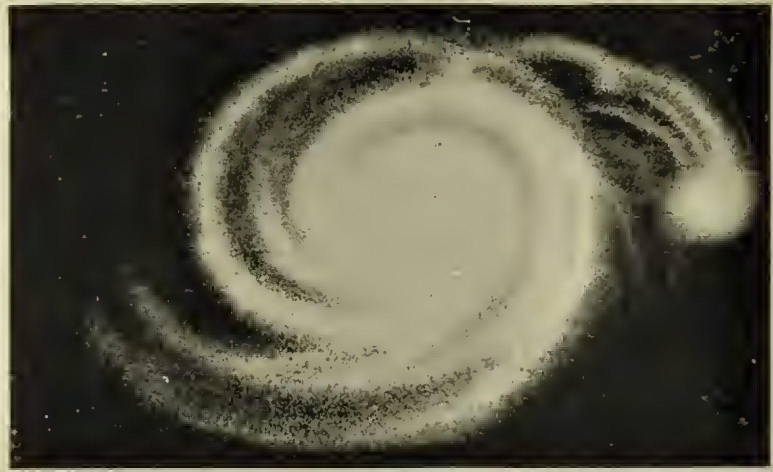
of interest from the effect which they have on the surface of the crust.

Atmosphere and Water. The atmosphere, or outer envelope of the earth, consists chiefly of the air we breathe, a mechanical mixture of the gases oxygen and nitrogen, in the proportions by volume of about 1 to 4—exactly 20·6 O to 79·4 N—with a small, varying amount of carbon dioxide and water vapour, and traces of rare gases like argon and helium. It extends perceptibly to a height of about 200 miles [see page 149], though more than half of it is compressed by gravity to within three miles of the surface. It is equal in weight to an envelope of water covering the whole earth to a depth of 34 ft., and exerts a pressure on all substances at sea-level of rather less than 15 lb. to the square inch (one atmosphere). Its geological effects are very considerable, as the rocks of the lithosphere are superficially modified by wind—laden with dust—rain, hail, and snow.

The *hydrosphere*, or surface water of the earth, also plays a great part in the work of geological change. This water is sufficient, if the surface were a dead level, to cover the whole earth to a depth of nearly two miles. But the various forces which have been at work in the course of the last hundred million years or so have modified the earth's surface so that it presents considerable inequalities of level [see pages 8 and 287]. Consequently, the water of the hydrosphere has chiefly collected itself into the seas which occupy the depressed portions of the surface, and which cover nearly three-fourths of the whole area of the earth — about 145,000,000 square miles. A considerable part of the water is always suspended as *vapour* in the atmosphere, and a complete system of circulation is set up under the solar influence. [See the course on GEOGRAPHY.] The water evaporates from the seas, falls as rain on the land, and is returned to the sea by the rivers which it thus forms. It is one of the most effective agents in the geological operations which are constantly altering the surface of the earth.

The Solid Earth. The great bulk of the earth consists of the *lithosphere*, or solid globe of rocks, with which geology properly deals. It is on the part of this lithosphere, composing a little more than a quarter of the earth's whole area—55,500,000 square miles—[see page 556] which rises above the seas and is called land, that mankind lives. Practically the whole of its surface is exposed to the study of the geologist, who is also acquainted with its interior structure, as displayed by mines and bore-holes, to the depth of something over a mile. It is his business to form inferences as to the condition of the parts which he cannot directly explore. He has also to tell us why the land is diversified so much, by plain and table-land, mountain-range and valley-system; why the rivers flow through it, and what dominant force has traced their courses; why one kind of soil is better suited than another to the purposes of agriculture; and how the miner can best prospect for the shafts with which he hopes to tap the mineral resources of the earth's interior. Only a long and thorough course of study can enable him to do all this, but the principles on which he depends are outlined in the following chapters.

Astronomy has already taught us that the earth was once so hot as to be a mere nebula, composed either of fiery gases or of glowing particles of matter such as we now call meteorites. We know, by common experience, that its surface is now cool and hard, and mostly composed of solid rocks, with a mantle of soil varying from one or two to hundreds of feet in thickness. How has this great change been brought about?



THE SPIRAL NEBULA IN CANES VENATICI, WHICH MAY INDICATE THE MANNER IN WHICH OUR EARTH WAS FORMED AGES AGO

Influence of the Earth's Motion. We know that three different agencies have been at work on the original nebula. It was originally in motion, rotating around its own axis, and this motion has been preserved and handed on to the earth. It was intensely hot, and has been losing heat ever since. And it was made up of some sixty or seventy different substances—the so-called elements of the chemist—which have since entered into numerous kinds of combination with one another.

The nebulous earth has constantly been losing *heat* by radiation out into space. All bodies, with some negligible exceptions, contract as they cool. Thus the nebulous earth steadily contracted as it lost heat, until finally it began to change from glowing gas into a very hot liquid—a globe of molten rock—from which, as we have seen, the moon was shot off under the influence of the centrifugal force.

The exact steps of this *liquefying process* are still in doubt. We can never hope to trace this far-off part of the earth's history with any great accuracy; it is so much a question of inference and hypothesis. Some hold that the liquefying process began at the centre of the nebulous mass, for, though the heat may have been greatest there, so was the pressure, amounting perhaps to 3,000,000 atmospheres, or 20,000 tons

to the square inch; and we know that the melting-point of nearly all substances rises in proportion to the pressure exerted on them. Others assert that it began at the outside, where cooling was fastest. What is certain is that it did begin somewhere, and continued until the whole vast nebulous bulk had shrunk into what we may for brevity call a liquid or plastic globe some 8000 miles in diameter.

The Solid Crust. Meanwhile, *chemical changes* have been going forward. At the high temperature of the original nebula it is probable that all the elements existed by themselves, being too hot to enter into combination. [See CHEMISTRY.] But as they cooled they began to form compounds; the iron and the oxygen rushed together, producing some oxide of iron; hydrogen and oxygen gave birth to water-vapour; silicon and oxygen produced quartz, and so on. Here the history of the earth belongs rather to chemistry than to geology.

The geological story really begins with the formation of the *solid crust* on the surface of this liquid globe. As the secular cooling went on, the outer parts of the liquid mass must have begun to harden and solidify, just as the lava from a volcano or the slag from a blast-furnace hardens when exposed to air. At first, no doubt, the hardened portions sank into the fiery liquid, and were dissolved again, but in time they began to become thicker and larger, and to adhere together, until at last the whole globe was covered with a skin of solid, though still intensely heated, rock. The atmosphere meanwhile shrouded this globe, and began to check the rate at which heat was lost; it contained not only the air which we breathe today, but all the water of the oceans and rivers in the shape of superheated steam, as well as vast quantities of carbon dioxide, much of which is now fixed in our coal-measures.

Heat of the Earth Within. An important evidence of the formation of this solid crust is to be found in the well-known fact that the earth is still *hotter within* than it is on the surface. The phenomena of volcanoes, geysers, and hot springs bear witness to the existence of some internal reservoir of heat. That this is not merely local, but universally distributed, is shown by the fact that wherever we bore into the earth's crust we find the temperature steadily increasing as we go down. On the average, the increase is 1° C. for every 90 ft. of descent. The actual rate varies widely according to the local conditions, but that is about the mean of numerous observations. If this rate were kept up, the temperature at the centre of the earth would be over 200,000° C. Probably the rate of increase does not remain so great; it must be remembered that we can follow it for only six or seven thousand feet. But there is no doubt that the interior of the earth is exceedingly hot. At a depth of 100 miles the temperature would be 5700° C. above that of the surface, and no known substance would in the ordinary course remain solid. Thus the earlier view of the earth held it to consist of a solid crust, 50 to 100 miles thick, floating on a molten globe, serving as the common reservoir for volcanoes.

Condition of Earth's Interior. But this view has been seriously modified by the progress of knowledge. Astronomers have shown that, if the earth's interior were really fluid, the sun and moon would cause vast tides in it which would seriously perturb the motion of our satellite. Nothing of the kind takes place, and it has been calculated with entire certainty that the earth, as a whole, must be far more rigid than if it were a globe of solid steel. The earlier geologists omitted to take account of the immense pressures which the weight of the superincumbent strata exerts upon the materials of the earth's interior, and which greatly raise the melting-point of the ordinary rocks. Thus, the modern view is that the interior of the earth is practically solid all through, in spite of the immense temperature which must prevail in it. The best theory is that of Professor Arrhenius, who has put forward the view that the earth is a vast bubble, consisting of a solid crust perhaps 30 or 40 miles thick, resting on a liquid magma of 60 to 100 miles, which shades off into a globe of gas.

But this gas is very different in physical properties from any which we know in our laboratories. That it is gas we argue, because the temperature at this depth must be higher than the critical temperature of any known substance—that is, the temperature at which a substance can remain solid or liquid under any pressure. [See PHYSICS.] But it is gas under a pressure so vast that its density is two or three times greater than that of any known rock, and its rigidity and incompressibility are greater than those of steel. Probably at least half of this gas consists of iron and other metals.

The Earth as it is. The earth, then, which geology has to study, consists of *a series of shells of matter* in different states. The *central core* is a globe of about 7600 miles in diameter, which is composed of iron and other elements, probably not forming compounds, in the gaseous state, but exposed to such tremendous pressure that it behaves as a solid and extremely rigid body. Outside this core is a *shell of liquid matter* which consists of all the rocks which we know at the surface in a state of fusion, perhaps 100 miles in thickness. Upon this magma floats the *solid crust*, 30 or 40 miles thick, which is composed of the various rocks which we have now to study, breaking down at the surface into soil. Three-fourths of the surface of this crust are covered by the *water of the oceans*, the hydrosphere, the rest being dry land. Outside all comes the *atmospheric mantle*, chiefly composed of air, which supports life, acts as a blanket to keep the earth warm, and as a shield against the blows of meteorites.

Before we can proceed to consider the later history of the earth, and to ask how the hot, bare rocks have given birth to the habitable earth on which we live, we must study the more important materials of which they are composed.

W. E. GARRETT FISHER

The Hydraulic Cylinder and Ram: Hydraulic Jacks of Various Types.
The Punching Bear and Wheel Press: Hydraulic Lifts and Cranes.

APPLICATIONS OF HYDROSTATICS

Hydraulic Rams. Pursuing the applications of hydrostatics into varied mechanisms, we find that the most important is the hydraulic cylinder and ram. In this appliance a solid ram or plunger fits within a cylinder into which water under pressure is admitted, thereby causing movement. The cylinder, or else the ram, is set in motion thereby. Generally it is the ram that moves, as in the hydraulic platform or station lift, and in baling presses, or flanging presses, types of a hundred other machines. But sometimes the cylinder is made free to move over the fixed ram, the alternatives being matters for convenience. Obviously, too, the positions of the mechanism are of no importance. Though in most cases set with the axis vertically, they are often horizontally, and in some cases inclined. Also the lift may be direct, the table platform, or platen, being attached to the head of the ram. Or chains may be brought round pulleys at the head of the ram, and, with suitable anchorages, used to impart motions that are not in a direct line with the movements of the ram. These occur in jigger hoists, and in many kinds of hydraulic cranes. Pressure is also often transmitted by jointed or walking pipes instead of rigid ones, to avoid having to reconnect, as in hydraulic riveting plants.

It should now be readily seen that, given the foregoing elements, capable of producing strong pressure and transmitting it by a liquid which is practically incompressible, enormous possibilities in application are opened up. The following are a few examples which are selected from a much wider practice, and each of which occurs in machines the details of which are modified in many ways in the hands of different manufacturers according to their needs.

The Hydraulic Jack. This is a simple machine for gaining enormous power, but with its accompaniment of very slow movement, resembling in this respect the differential pulley blocks. Both are invaluable when heavy loads have to be lifted by human energy alone. The jacks will lift locomotives, ships, bridges, by the operation of a hand lever, and in modified forms they will push loads slowly. They are emergency tools out of doors, where cranes are not available. Their general construction is shown in **103**, which represents a Tangye lifting-jack that combines two functions in one—that of lifting on the head A, and also on the foot B, the latter being an invaluable addition when there is little space between the object to be lifted and the ground. The construction of the jack is as follows.

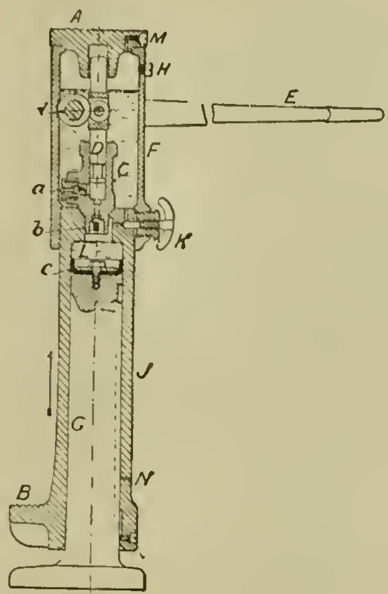
C is the body of the force-pump, and D its ram, actuated by the lever E, drawing the water from the cistern F, by the pressure on which between the ram G and the casing J the latter is forced upwards. In the force-pump CD we recognise the same type of pump that was illustrated in the previous article [page 1568]. The difference in the area of the ram D and that of the ram G of the jack represents the theoretical gain in pressure.

Operation of the Jack. When in operation, the cylinder J should first be down to the bottom of the ram, as shown by the drawing. The cistern F is then filled with liquid, either by removing the cover A or by taking out the charging screw H and filling through its hole. Clean water must be used, or rain water, or condensed steam with ¼ oz. of soda added. In cold weather glycerine is added to the water to prevent freezing—one part of glycerine to three of water. The lowering screw, or stop-valve K, is then unscrewed, and the lever E, pivoted at *d*, worked a few times, by which means water is forced through the pump into the space L, and any air present passes through the valve K into the cistern F. A little more water is added through H to take the place of the air driven out. The air-screw M is left slightly opened all the time to allow freedom of escape to the air. The cylinder J rises on the ram G until the water comes out of the blowhole N, though it is not well to lift to the extreme limit, as the leather packing (*c*) is liable to become damaged.

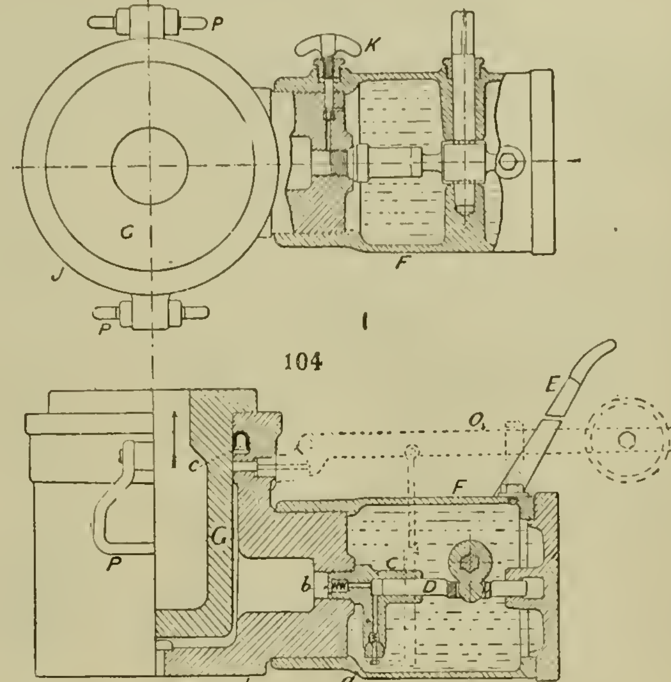
To lower the jack, the screw K is slackened, which leaves a free passage of the liquid from L to F. If the height to which a load has to be lifted exceeds that of a single "run-out" of the jack, then the jack is raised on blocking, and another lift taken.

There are a good many practical points about the working of these jacks, but only one can be referred to here—the care of the leather packings (*c*). Nothing yet has been substituted successfully for leather, so that the old saying "nothing like leather" is in this connection absolutely true. A peculiarity to be noted is that the leather is cupped in such a way that the harder the pressure the more tightly is the leather pressed out against the walls of the cylinder. Sometimes even a leather which will be leaking when a ram is doing no work will cease leaking as soon as a load is put on. The troubles to which leathers are liable are mainly due to their drying and shrinking. Next to these the presence of grit is most harmful. When leathers have to be cleaned they are taken out and soaked in water or oil.

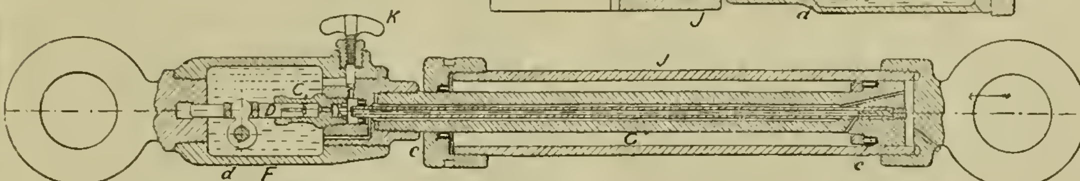
With regard to lifting a load on the claw B, it is obvious that the full load which can be taken on the head A cannot be put on the claw. It is, therefore, not judicious to carry more than



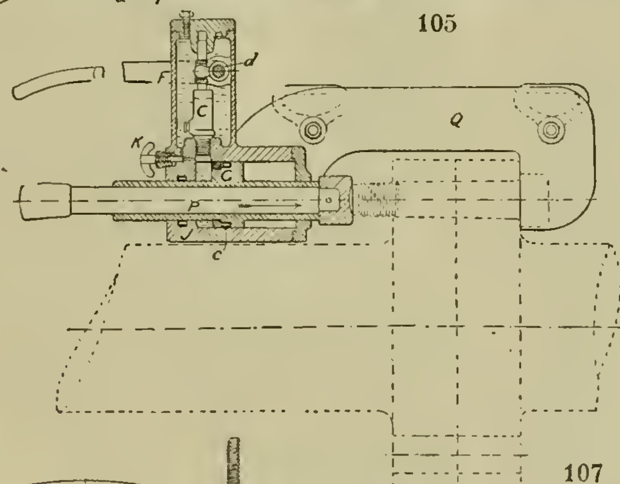
103



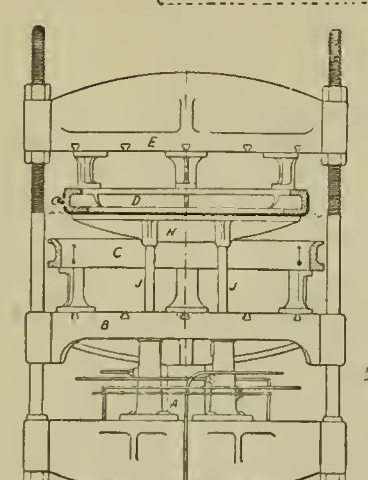
104



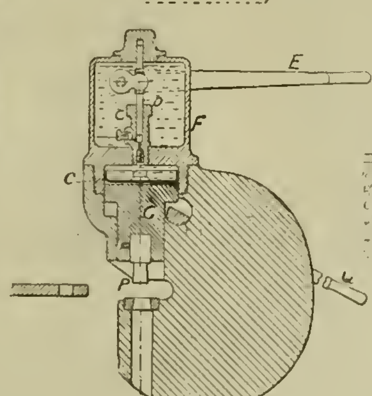
105



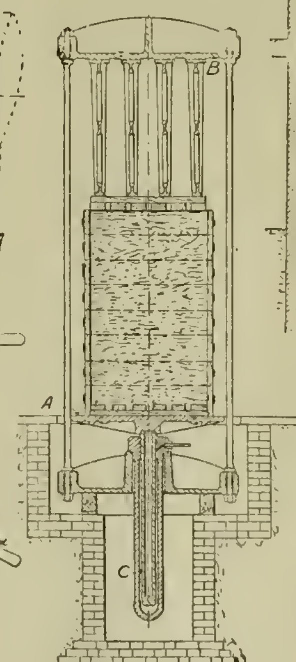
107



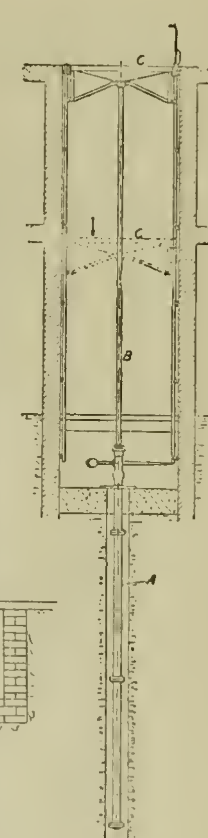
109



106



108



110

103-110. HYDRAULIC PRESSURE MACHINES

25 per cent. of the jack-load on the claw if the lifting be a high one. For a short lift nearly the maximum load may be carried with safety.

Modified Jacks. Around this simple mechanism, which is but a modified form of the essential Bramah press, engineers have built many designs, a few of which we shall now notice. Some of the reference letters are retained in the subsequent figures for the purpose of ready identification of similar parts in other machines.

Given the jack itself, one of the first improvements effected with a view to increase its range is to impart a horizontal motion bodily to it—the *traversing jack*, a movement effected by a screw. An object after being lifted can thus be moved along bodily within a limited distance by this type of jack.

Ship Jacks. Jacks are utilised for lifting ships, hence termed ship jacks [104], though, of course, suitable also for bridges and other heavy works. Here we recognise the force-pump, but set in a horizontal direction, and operating a vertical ram. But while the jack in **103** is made for loads up to about 50 tons, the ship jack is made as high in power as 400 tons, which explains the enormous disproportion in the diameter of the rams D and G in **104**, the drawing being made to scale. Note also the great thickness of the metal in the cylinder J which encloses the ram, and receives the pressure tending to rupture it. The only other differences that need be noted are the form of the packing leather, and the safety-valve in **104**. The leather (*c*) is of the U section, that being more suitable than the cup form in **103** for withstanding enormous pressures. The weighted safety-valve lever O, though often omitted, is desirable because of the severity of the pressure, which, if much exceeded, might rupture the cylinder or the pump. The power of this small jack is thus equal to the lifting of four of the largest locomotives with their tenders.

Pulling Jacks. In these examples the power is applied to the exercise of thrust or push, but it is equally applicable to a pull. A special form, therefore, is the pulling type [105]. There are confined spaces where even the snug pulley-blocks cannot be used to pull a load, as in shaft tunnels, and sometimes in the engine-rooms of steamers, and then the pulling jack, operated by a pressure pump, is a boon to the men who have to execute hurried repairs.

This jack has the same cistern, force-pump, and stop-valve, but a tube (G) takes the place of the ram, and the water pumped from the cistern passes through the bore of this tube to the underside of the piston. The latter forms an enlargement at the end of the tube, and has a U leather packing (*c*). The eyes fitted at the ends are in union, one with the cistern and thence with the tube, the other with the cylinder for connecting to the work, and to any suitable point of attachment. In operation, the tube is drawn out as far as is required, and the act of pumping pulls it in, drawing the work along with it. The jack is used indifferently in a vertical or horizontal position. Machines of this kind are made with powers as high as a 25-ton pull, with a maximum run-out of 36 in.

The Punching Bear. Nor is it only in pushing and pulling that the coercion of pressure-water is in evidence. The same essential mechanism—that of the small ram of a pump and the large-power ram—are used for punching holes through steel, and for shearing the edges of steel sheets. Fig. **106** shows one of the first variety, which is made by Messrs. Tangye, of Birmingham, a most useful machine, termed the punching bear. Its utilities lie in the formation of holes in girders and other plated work in localities which do not admit of the utilisation of the fixed power operated machines. A man or two men can handle this machine, yet it is powerful enough to drive rivet-holes through iron plates $\frac{3}{4}$ or 1 in. thick.

The top lever E actuates the force-pump, and sends pressure-water into the chamber above the ram G, pushing the latter down. The punch P being fitted into a hole in the latter partakes of its movement. The function of the lower lever Q is to raise the ram and punch, previous to which the stop-valve must be opened to allow of the escape of the water back into the cistern.

Around this design many larger punching machines are built for special work. They include machines for punching tram rails, girders, channels, and copper sheets. Some are portable, being mounted on wheels for movement to work in progress, on railways, and in streets. Some have so little resemblance to others that a superficial observer would hardly see the relationship, but they all embody the same principle—that of the Bramah press. Some, too, are used for closing rivets. Also, by substituting shear blades for the punch and its bolster, we have the hydraulic shearing machines, a large group now extensively used.

The Wheel Press. This is a machine for pulling railway wheels on their axles, and taking them off by the simple exercise of water-pressure. The wheels on their axle are slung between heads, which afford the necessary resistance to the water pressure. They are capable of exercising total pressures ranging from 80 to 200 tons. Many of these are worked from an accumulator.

Bolt Forcer. The same principle is adopted in the bolt forcer [107], a small machine which pushes bolts home, and rusty ones out of their holes. They are capable of exerting pressures of from 20 to 75 tons on a refractory bolt. The ram here (G) is hollow, to receive a steel drift (P) which is forced along by the ram against the tail of the bolt to be pushed out. The resistance is taken by the arms or claws Q, two in number, so flanking the bolt on each side. A propeller shaft with a bolt about to be forced out of the flange is indicated in dotted outlines. The arms (Q) have handles for lifting and transportation. Figs. **104**, **105**, and **107** illustrate examples from the practice of Messrs. Youngs, of Birmingham.

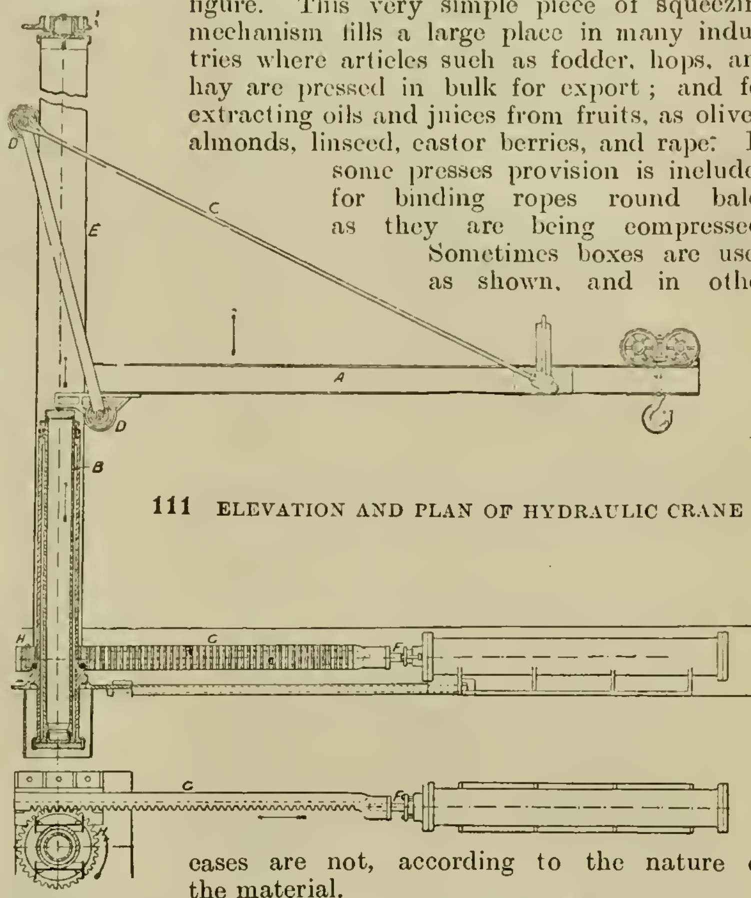
Another machine forces the big propellers of ships off their shafts by the persuasive power of a little water judiciously applied.

Yet another group identical in principle of operation include the bending and straightening machines. These may often be seen in the streets where tram-lines are being laid down. Pressure either to bend or straighten is applied between the end of the ram and a pair of claws, or hooks, opposed thereto, and to right and left, the rail being gripped between so that the pressure takes place at three points. Pressures of 40, 50, or 60 tons are thus obtainable.

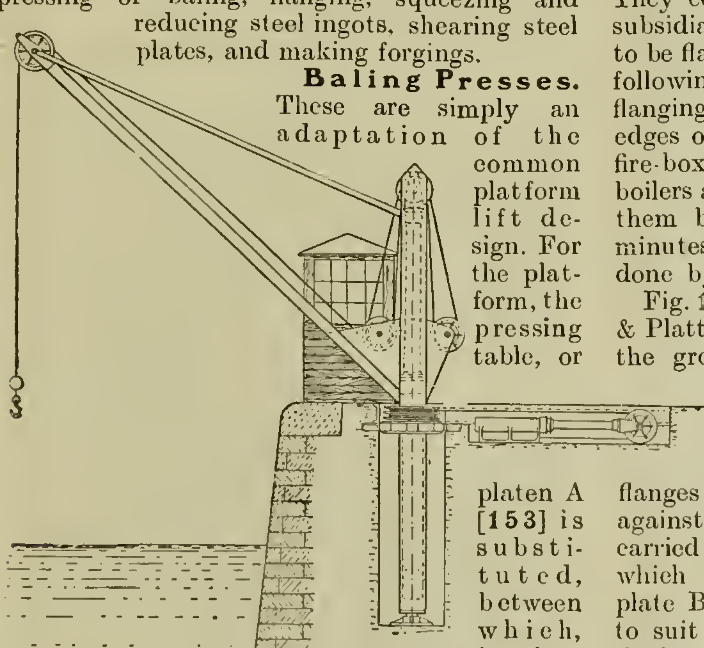
In the shops there are larger machines used for straightening steel beams, precisely the same in essential mechanism, but differing in outline, being fixed on massive bed-plates. When steel girders, joists, bars, and other sectional forms have to be either bent or straightened, this is not done by the brutal method of hammering, but by squeezing. The machine may be described as a hydraulic jack (the ram) so mounted as to push the girder or beam in opposition to two points of resistance. Being under control, the pressure can be arrested when the beam is either straightened or bent to the curvature required.

Presses Using Accumulators. The members of this group are as numerous as those we have already considered, and they are generally much more massive in form. The most familiar are those for lifts for passengers and goods, for pressing or baling, flanging, squeezing and reducing steel ingots, shearing steel plates, and making forgings.

Baling Presses. These are simply an adaptation of the common platform lift design. For the platform, the pressing table, or platen A [153] is substituted, between which, in its upward movement and the head B of the machine, fixed above, the loose material is pressed, often with a force of from two to three tons on every square inch. Hay is pressed thus into a bulk one-sixth that of the original truss. The motive power is still the force-pump and accumulator actuating the ram C in the figure. This very simple piece of squeezing mechanism fills a large place in many industries where articles such as fodder, hops, and hay are pressed in bulk for export; and for extracting oils and juices from fruits, as olives, almonds, linseed, castor berries, and rape. In some presses provision is included for binding ropes round bales as they are being compressed. Sometimes boxes are used as shown, and in other cases are not, according to the nature of the material.



111 ELEVATION AND PLAN OF HYDRAULIC CRANE


112 HYDRAULIC CRANE

Flanging Presses. These are a special variant on the baling press and kindred types. They contain more mechanism, in the form of subsidiary side-rams, that push the boiler plate to be flanged up against one die, which is fixed, following which the main ram pushes the flanging, or movable die up, so bending over the edges of the plate against the fixed ram. The fire-box and tube-plates for locomotive and other boilers are turned round thus, instead of flanging them by hand, the process occupying a few minutes against hours required when they are done by hand hammers.

Fig. 109 illustrates a flanging press by Fielding & Platt, Ltd. The cylinder and ram are below the ground, as in the baling press, but only the top of the ram is shown in the figure, at A. This lifts the movable plate B, which carries the lower flanging die C on stools, which die flanges or turns over the edges of the plate G against the edges of the upper die D. D is carried by stools against the fixed plate E, which thus resists the pressure of the lower plate B. E is, however, adjustable in height to suit different pieces of work and different thicknesses of dies. Before the actual flanging of the plate G takes place, the plain plate is brought up and held against the upper die D by the plate H, which has a vertical movement independent of that of B through

four small hydraulic rams J. The object of this provision, distinct from the squeezing, is to permit of making precise adjustments of the plate before flanging it. Hundreds of these machines are in use, doing work with a silent squeeze better, as well as more quickly, than hand work was ever capable of doing.

Forging Presses. These form an immense group, comprising machines more or less specialised. The largest forging press in the world is the 14,000-ton press of the Bethlehem Steel Works. There are some immense presses in Sheffield for forging down ingots for armour plates. Essentially they comprise the ram and cylinder. They have entirely displaced steam hammers for the most massive work. It would be impossible to forge the big propeller shafts and the guns and armour plates by steam hammers with sound results, to say nothing of the concussion of hammers, which does not exist with presses.

In forging presses are included large groups which deal with comparatively light work, which they bend and mould in all conceivable shapes. At the Swindon G. W. R. Works and elsewhere there are numbers of these presses in a great shop in silent operation making buffers, horn blocks, and the numerous forgings required for carriages and waggons.

Lifts. In the direct-acting lift [**110**] the hydraulic cylinder A is sunk in the basement. By the admission of pressure-water from the accumulator, the ram B is lifted. As it carries the platform C on its upper end, the platform partakes of the lift movement, and is carried up to a distance corresponding precisely with the amount of vertical travel of the lift. The descent is accomplished by gravity, by letting out the water, the rate of which is under control. The capabilities of this simple mechanism are almost without limit. Two extremely powerful installations of this kind are the canal lifts at Les Fontinettes, and on the Canal du Centre, Belgium. In the latter a trough of water, weighing 1,100 tons, and containing a barge, is lifted to a height of 50 ft. in $2\frac{1}{2}$ minutes. This load is sustained by one ram 6 ft. $6\frac{3}{4}$ in. diameter, and the pressure is 470 lb. to the square inch. On the Neuffossé Canal, at Les Fontinettes, similar lifts, but weighing 700 tons, are lifted 43 ft.

Hydraulic Cranes. As these were the first mechanisms to which water pressure was applied (by Armstrong, at Newcastle), so they are still used to an immense extent for light as well as heavy loads. Details vary widely from the plain types shown in **111**, **112**, to the vast coal-tips which lift a 20-ton waggon of coal, tip it, and return the waggon to the rails in a period of time as brief as a minute.

The crane shown in **111** is of the direct-acting type—that is, the jib A with its load is lifted by the upward movement of the ram B. The jib is steadied by the rods C and rollers D above and below against the post E. The rotation of the jib is accomplished by another ram (F), set horizontally, and moving a rack (G), turning a wheel (H) that encircles the post E. More often a chain is used for turning, as indicated in the skeleton drawing **112**. In this example the lifting of the load is done with a fixed jib. The ram is shown at the top of its stroke, and its movement draws the rope or chain round the pulleys shown, so lengthening or shortening the lift at the hook.

Other Applications of Hydrostatic Pressure. The foregoing is a small but representative selection of the utilities of power-water. The following is a short summary only of other ways in which hydrostatic pressure is employed in engineering structures.

It is applied in many turning operations, for, as we have seen, the cylinders can be arranged in any positions, and connected by chains or racks and pinions to the parts to be moved. Hence we have it working the steering gear of the largest ships, for which hand power would be utterly incompetent. Large swing-bridges are operated similarly. There are many of these in existence for road and railway traffic. One of the latter, over the River Ouse, at Goole, weighs 670 tons, and is actuated by engines having three cylinders arranged radially, and worked by water at a pressure of 700 lb. per sq. in. One over the River Tyne weighs over 1,200 tons. The huge bascules of the Tower Bridge are raised and lowered by hydraulic engines, besides which the hoists for taking foot passengers up to and down from the high-level footways are actuated hydraulically.

Dock gates are opened and closed by hydraulic rams, arranged horizontally, and connected with chains to the gates. In other cases the chains are wound on to, or unwound from, drums by hydraulic engines. Docks having openings as wide as 100 ft. have their gates opened and closed thus by pressure-water.

Big guns are also manipulated hydraulically, and the recoil also taken thus.

Mention has been made of the hydraulic punch, the shearing and flanging machines, but these are only faintly representative of the vast utilities of the pressure-water in our factories and on public works. Numbers of distinct and separate types of machine tools, some fixed, others portable, are in use in nearly every big engineers' works and on great public structures. A modern boiler is never built without the aid of these tools; seldom, if ever, is a bridge erected or a steel ship constructed without their having a big share in the work. It would be difficult to say which is the more useful—the heavy, fixed machines, or the lighter, portable kinds. The latter enable many operations to be performed that a few years ago were deemed impossible except by hand work—operations done in awkward situations and where the work is too massive to be taken to any machine. Holes are punched and drilled, rivets closed, and steel cut, control being exercised by the movements of simple valves operated by handles. But the power behind it all is the pressure-pump and the accumulator, with its storage.

JOSEPH G. HORNER

Latin : Important Idioms. English : Parsing and Analysis.
French : Numerals. German : Strong Verbs and Adverbs.

LATIN

Continued from page 1572

By Gerald K. Hibbert, M.A.

Section I.

Miscellaneous Idioms

English.	*Latin.*
Calpurnia married Cæsar.	Calpurnia Cæsari nupsit (lit., *veiled herself for Cæsar*).
Cæsar married Calpurnia.	Cæsar Calpurniam in matrimonium duxit.
He is the best scholar in the school.	Discipulorum, si quis alius, ille optime discit.
It does not fall to the lot of everybody to visit Naples.	Non cuilibet contingit Neapolim videre.
There are some who think you are mad.	Sunt qui putent te insanire.
I prefer a thousand deaths.	Malo sexcenties mori (the Latins always said *six hundred times* in such sentences).
I fear you are wrong.	Timeo ne erres.
I fear you are not wrong.	Timeo ut erres.
I will do it if I can.	Hoc si *potero* (*fut.*) faciam.
He pities no one.	Nullius miseretur (not *neminis*: gen. and abl. of *nemo* not used. "With *nemo* let me never see *Neminis* and *nemine*.")
I am sorry to say this.	Invitus hoc dico.
He perished in his youth.	Juvenis mortuus est.
I have asked him to come to see me as quickly as possible.	Rogavi eum ut quam celerrime veniat me visum (*supine*).
I cannot write for weeping.	Præ lacrimis scribere non possum.
One uses one tent, another another.	Alius alio tabernaculo utitur.
All the best citizens are present.	Optimus quisque civis adest.
It is all over with me.	Actum est de me.
You ought to have done it before.	Antea te hoc facere oportuit (*note the pres. infinitive*).
On the march.	Ex itinere.
On horseback.	Ex equo.
He departed without asking what I had done.	Discessit, neque quid fecissem rogavit (*or*, Ita discessit ut non rogaret, etc.). But not *sine* with gerund.
With your usual kindness.	Pro tua clementia.
In front was the sea, in our rear the enemy.	A fronte mare, hostes a tergo imminebant. (Note the "back to back" construction, called Chiasmus, *mare* and *hostes* being the two means, *a fronte* and *a tergo* the extremes).
He came sooner than he was expected.	Opinione celerius venit.
The House divided on the motion.	Pedibus in sententiam iverunt.
Once every four years.	Quarto quoque anno.
I am on the point of going.	In eo sum ut proficiscar.
In the open air.	Sub divo.
The sisters loved one another.	Sorores altera alteram amaverunt.
I was within an inch of death.	Minimum abfuit quin morerer.
Mind you come.	Cura (*or* Fac) ut venias, *or simply* Cura venias. (*Cura* is imperative of *curo*, *curare*.)
He is not a fit person for you to converse with.	Non est aptus quocum colloquaris.
I cannot walk even a mile, not to mention seven.	Ne mille passus quidem ambulare possum, nedum septem (millia passuum).
At one time he is wise, at another a perfect fool.	Modo sapiens, modo stultissimus est.
Some laws were passed, others remained posted up.	Leges aliæ latæ sunt, aliæ promulgatæ fuerunt.
What is the meaning of the word pleasure ?	Quid vult vox voluptatis ?
I asked him what time it was, but he made me no reply.	Mihi interroganti quota hora esset, nihil respondit.
I am writing this letter on the 1st of April.	Has literas (*or* hanc epistolam) Kalendis Aprilibus scribebam. (Epistolary imperfect, because to the reader the writing is *past*.)
It would be tedious.	Longum est.
It would have been better.	Melius fuit.

English.	*Latin.*
All the world knows that you are not convinced.	Nemo est quin sciat tibi non persuasum esse.
Instead of thanking me, he abused me.	Quum gratias mihi agere deberet, mihi maledixit.
"This, then, is the reason why pay has been granted to the soldiers: nor has it escaped our notice that this gift will be daubed with the poison of our enemies. The liberty of the people has been sold: our soldiery is removed for ever and banished from the city and from the republic: no longer do they give way even for winter or the season of the year and visit their homes and possessions. What do you think is the reason for this prolonged service?"	*In Oratio Obliqua.* Hoc illud esse quod æra militibus sint constituta; nec se fefellisse, id donum inimicorum veneno illitum fore. Venisse libertatem plebis; remotam in perpetuum et ablegatam ab urbe et ab republica juventutem jam ne hiemi quidem aut tempori anni cedere ac domos ac res invisere suas. Quam putarent continuatæ militiæ causam esse? (Livy.)
The top of the mountain.	Summus mons.
From day to day.	Diem de die.
To be brief.	Quid plura [dicam]?
As far as I know.	Quod sciam.
No letter from you.	Nulla tua epistola.
Every fifth year.	Quinto quoque anno.
To make many promises.	Multa polliceri.

SECTION II.

Definitions of Grammatical Terms

Asyndeton. The annexing of words without a conjunction—*e.g.*, *di, homines* (gods and men).

Aposiopesis. A sudden stopping on the part of the speaker, as though unwilling or unable to proceed—*e.g.*, Æneid I., 135:
"*Quos ego—sed motos præstat componere fluctus.*"

Hendiadys. The presentation of one and the same notion in two expressions—*e.g.*, "with might and main." *Chlamydem sinūsque* (the folds of the cloak: literally, the cloak and the folds).

Enclitic. A word or particle which always follows another word, so united to it as to seem a part of it—*e.g.*, -que, -ve.

Patronymic. A title expressing descent from a father or ancestor—*e.g.*, *Alcides* = son of Alceus; *Anchisiades* = son of Anchises.

Syncope. The shortening of a word by casting out an inner vowel; as, *patri* (*pateri*).

Synesis. A construction in harmony with the sense rather than with strict syntax—*e.g.*, *subeunt juventus auxilio tardi* = the young men come up slowly to the rescue. Here *subit* and *tarda* would have been strictly needed.

Crasis. The contraction of two vowels into one long vowel or into a diphthong.

Zeugma. The using of one verb in two different senses—*e.g.*, Æn. I., 264: *mores et mœnia ponet.*

Oxymoron. An apparent contradiction in terms—*e.g.*, *splendide mendax*: *insepultam sepulturam* (a mockery of burial).

Periphrastic Conjugation. The participles in *urus, dus* may be conjugated with all the tenses of *sum*—*e.g.*, to form fut. subj. of *amo*, "*amaturus sim.*"

Litotes. Understatement, saying less than one means—*e.g.*, "a citizen of no mean city," *non innoxia verba* (deadly words).

Hysteron-Proteron. The idea, logically second, being put first—*e.g.*, *moriamur, et in media arma ruamus.*

Chiasmus. Contrast obtained by reverse order—*e.g.*, *urbi Cæsarem, Brutum Galliæ* (*dederunt*).

Anaphora. Repetition of the verb to avoid the use of a conjunction—*e.g.*, *Venit et upilio; tardi venere subulci* (Virgil, Eclogues X., 19).

PASSAGE TO BE RENDERED INTO LATIN

A CHARACTER SKETCH.

He belonged to those thin and pale men, as Cæsar names them, who sleep not in the night and who think too much; before whom the most fearless of all hearts has shaken. The quiet peacefulness of a face, always the same, hid a busy, fiery soul, which stirred not even the veil behind which it worked, and was equally inaccessible to cunning or love; and a manifold, formidable, never-tiring mind, sufficiently soft and yielding momentarily to melt into every form, but sufficiently proved to lose itself in none, and strong enough to bear every change of fortune. None was a greater master than he in seeing through mankind and in winning on hearts; not that he let his lips, after the manner of the court, confess a bondage to which the proud heart gave the lie; but because he was neither covetous nor extravagant in the marks of his favour and esteem, and by a prudent economy in those means through which one binds men, he multiplied his real store of them. Did his mind bear slowly, so were its fruits perfect; did his resolve ripen late, so was it firmly and unshakably fulfilled. The plan to which he once had paid homage as the first, no resistance would tire, no chances destroy; for they had all stood before his soul, before they really took place. As much as his mind was raised above terror and joy, so much was it subjected to fear; but his fear was there earlier than the danger, and in the tumult he was tranquil because he had trembled when at rest.

LATIN VERSION OF THE ABOVE PASSAGE.

Erat profecto e pallidis illis macilentisque viris quos dicit Cæsar [*or*, ut Cæsarianum illud usurpem] qui insomnia et nimia cogitatione exerciti terrorem aliquando vel fortissimis incusserunt. Vultui tranquillo et immobili suberat acer fervidusque animus, qui ne involucrum quidem sibi operanti quasi prætentum commovebat, contra fraudem et studia pariter obstinatus: suberat ingenium multiplex, formidulosum, indefessum, ita facile ut nullam non ex tempore formam indueret, ita duratum

ut nunquam a sua ipsius natura decederet, ita validum ut omnes fortunæ vicissitudines impune sustineret. Hominum indoles, ut nemo alius, perspiciebat, conciliabat gratiam: quem tamen ne putes, urbanorum more, obsequium, quod infitiaretur contemptor animus, ore professum esse, sed potius officiosæ benevolentiæ neque parcum neque prodigum, opes, quibus devinciuntur homines, caute dispensando auxisse. Mens ejus, si tardiores, perfectos certe edebat fructus; consilia ut serius provenissent, constanter tamen et sine vacillatione peragebantur. Propositum, cui semel primas detulisset, nulla vis oppugnantium frangere, nullæ vices labefactare poterant, quippe quas omnes animo jamdudum præcepisset. Quantum super terrores et gaudia elata erat mens ejus, tantum timori erat subjecta: præveniebat vero timor ille periculum, adeo ut qui in tranquillo trepidavisset, in trepidatione ceterorum maneret tranquillus.—(J. Conington.)

Section III. TRANSLATION.

Passage from Virgil's Eclogues, or Pastoral Poems.

"THE GOLDEN AGE."

[*Virgil expresses the general hopes of a new era of peace and prosperity in language suggestive of the return of a bygone age of gold, connecting this age with the birth of a boy expected in this year*, B.C. 40.]

At tibi prima, puer, nullo munuscula cultu
Errantes hederas passim cum baccare tellus
Mixtaque ridenti colocasia fundet acantho.
Ipsæ lacte domum referent distenta capellæ
Ubera, nec magnos metuent armenta leones.
Ipsa tibi blandos fundent cunabula flores.
Occidet et serpens, et fallax herba veneni
Occidet; Assyrium vulgo nascetur amomum.
At simul heroum laudes et facta parentis
Jam legere et quæ sit poteris cognoscere virtus,
Molli paulatim flavescet campus arista,
Incultisque rubens pendebit sentibus uva,
Et duræ quercus sudabunt roscida mella.
Pauca tamen suberunt priscæ vestigia fraudis,
Quæ tentare Thetim ratibus, quæ cingere muris
Oppida, quæ jubeant telluri infindere sulcos.
Alter erit tum Tiphys, et altera quæ vehat Argo
Delectos heroas; erunt etiam altera bella,
Atque iterum ad Trojam magnus mittetur Achilles.
Hinc, ubi jam firmata virum te fecerit ætas,
Cedet et ipse mari vector, nec nautica pinus
Mutabit merces: omnis feret omnia tellus.
Non rastros patietur humus, non vinea falcem;
Robustus quoque jam tauris juga solvet arator;
Nec varios discet mentiri lana colores,
Ipse sed in pratis aries jam suave rubenti
Murice, jam croceo mutabit vellera luto;
Sponte sua sandyx pascentes vestiet agnos.
'Talia sæcla,' suis dixerunt, 'currite' fusis
Concordes stabili fatorum numine Parcæ.

Translation of the above Passage.

On thee, child, the earth shall begin to lavish without aught of tillage her simple gifts, straggling ivy twined with foxglove, and colocasia (the Egyptian bean) with smiling bear's-foot. Of their own accord the she-goats shall bring home their udders swollen with milk, and the herds shall not dread the mighty lions. Thy very cradle shall pour forth flowers to caress thee. The serpent, too, shall perish; perish likewise the treacherous poison-plant. Eastern spice shall spring up everywhere. But so soon as thou shalt be able to learn the exploits of heroes and the deeds of thy father and what their manly virtue is, gradually the plain shall turn yellow with waving corn; on wild brambles shall hang the ruddy grape, and sturdy oaks exude the dew-born honey. Yet shall there lurk a few traces of early guile, to bid men tempt the sea with barks, gird cities with walls, and cleave the earth with furrows. Then shall be a second Tiphys (helmsman of the Argo) and a second Argo to carry the chosen heroes; there shall be the old wars repeated and a great Achilles sent again to Troy. Next, when thy full-grown strength has made thee a man, even the merchant shall quit the sea, and the pine-built ship shall not exchange its wares: every land shall bring forth everything. The ground shall not endure the hoe, nor the vineyard the pruning-hook: the stout ploughman, too, shall now loose his oxen from the yoke. Wool shall not learn to assume divers colours, but by Nature's gift (ipse) the ram in the meadows shall exchange his fleece for sweetly-blushing purple and for saffron dye. Of its own accord scarlet shall clothe the browsing lambs. "Ages like these, run on!" said the Parcæ to their spindles, uttering in concert the fixed will of Fate.

Those desirous of pursuing Latin Prose further are recommended to use Abbott's "Latin Prose through English Idiom"; "Arnold's Latin Prose Composition," by Bradley; and "Translations," by Messrs. Jebb, Jackson, and Currey (George Bell and Sons), to all of which books, with the addition of Roby's Latin Grammar and the Public School Latin Primer, the writer wishes to acknowledge his indebtedness.

We now pass to a subject which requires a very careful study of Latin quantities—the making of Latin verse.

Continued

ENGLISH

Continued from page 1576

By Gerald K. Hibbert, M.A.

PARSING

We have now gone through all the parts of speech in detail, and have been "parsing" words, perhaps unconsciously, throughout the process. For to "parse" a word is simply to say to what part of speech it belongs, and how it is related to other words in the same sentence.

Parsing Scheme. 1. Noun. Give (1) general class—*i.e.*, proper, common, abstract,

collective; (2) gender; (3) number; (4) case; (5) reason for the case.

2. ADJECTIVE. Give (1) class, whether of quality, quantity, or relation; (2) degree, whether positive, comparative or superlative; (3) its qualification of the substantive. If the adjective in question is pronominal—*i.e.*, also used as a pronoun—state this in parsing it.

3. PRONOUN. Give (1) class, (2) gender (if possible), (3) number, (4) case, with reasons for the number and the case.

4. VERB. If a finite verb, give (1) voice, (2) mood, (3) tense, (4) number, (5) person, and the subject with which it agrees.

If an infinitive or gerund, give (1) voice, (2) tense, (3) case, with a reason for the case.

If a participle, give (1) voice, (2) tense, (3) number, (4) case, and the substantive with which it agrees.

In *all* moods, say whether the verb is transitive or intransitive, whether of weak conjugation or of strong, and give the principal parts of the verb—*i.e.*, present indicative, past indicative, and past participle.

5. ADVERB. Give (1) class, (2) degree, (3) what it qualifies.

6. PREPOSITION. State what it governs.

7. CONJUNCTION. Give its class, and say what sentences or words it connects.

Example of Parsing.

"But then the mind much sufferance doth o'erskip,
When grief hath mates, and bearing fellowship"
("King Lear.")

But. Co-ordinative conjunction, connecting this sentence with what has gone before.

Then. Adverb of time, modifying "doth o'erskip."

The. Demonstrative adjective, pointing out "mind" (sometimes called definite article).

Doth o'erskip. Verb, transitive, weak conjugation, active, indicative, present, singular, third person, agreeing with its subject "mind," from *o'erskip, o'erskipped, o'erskipped.*

When. Relative adverb (or conjunctive adverb) of time, modifying "hath."

Grief. Abstract noun, neuter, singular, nominative, because subject to "hath."

Hath. Verb, notional (not auxiliary here), transitive, weak, active, indicative, present, singular, third person, agreeing with its subject "grief," from *have, had, had.*

Mates. Common noun, common gender, plural, objective after "hath."

And. Co-ordinative conjunction, joining the two sentences "Grief hath mates," and "Bearing (hath) fellowship."

Bearing. Abstract noun, neuter, singular, nominative, subject to "hath" understood

Fellowship. Abstract noun, neuter, singular, objective after "hath" understood.

N B. Parse compound tenses of a verb—*e.g.*, *have been, shall be leaving,* all as one word. We could, of course, split them up and parse the words separately, but there is no need to do this.

ANALYSIS

Complex Sentences. The method of analysing simple sentences was given on page 788. When we analyse a complex sentence, we first pick out the principal clause, and insert the subordinate clauses as parts of the principal clause. Then we analyse the different subordinate clauses, omitting the connecting words.

For example:

"There is some soul of goodness in things evil
Would men observingly distil it out."

The principal clause is "There is some soul of goodness in things evil," and the subordinate clause "(If) men would observingly distil it out."

SUBJECT.	LIMITATION OF SUBJECT.	PREDICATE.	LIMITATION OF PREDICATE.	OBJECT.
soul	(*a*) some (*b*) of goodness	is	(*a*) in things evil (*b*) would men observingly distil it out	——
men	——	would distil	(*a*) observingly (*b*) out	it

Mind. Abstract noun, neuter, singular, nominative because subject of "doth o'erskip."

Much. Adjective of quantity, positive, qualifying with "sufferance."

Sufferance. Abstract noun, neuter, singular, objective, governed by "doth o'erskip."

Again:

"If you catch him when you reach home, give him the message which I will give you now."

The principal clause is "give him the message"; the other three clauses are subordinate.

1. Principal Clause

SUBJECT.	LIMITATION OF SUBJECT.	PREDICATE.	LIMITATION OF PREDICATE.	OBJECT.	LIMITATION OF OBJECT.
(you)	——	give	(*a*) him (*b*) if you catch him when you reach home	message	(*a*) the (*b*) which I will give you now

2. Subordinate Clauses

(*a*) If you catch him when you reach home.

you	——	catch	when you reach home	him	——

(*b*) When you reach home.

you	——	reach	home	——	——

(*c*) Which I will give you now.

I	——	will give	(*a*) You (*b*) now	which	——

Classification of Clauses. As has been mentioned previously, there are three kinds of clauses:

1. Clauses that play the part of a substantive in relation to some part of the sentence—*i.e.*, *Substantival* clauses.

2. Clauses that play the part of an adjective in relation to some part of the sentence—*i.e.*, *Adjectival* clauses.

3. Clauses that play the part of an adverb in relation to some part of the sentence—*i.e.*, *Adverbial* clauses.

Examples. SUBSTANTIVAL: "We know *that you are wrong*" (this clause is the object of "know"); "*When the election will come* is uncertain" (this clause is the subject of "is").

ADJECTIVAL: "Give me the portion of goods *that falleth to me*" (qualifies "portion"); "That is the spot *where Nelson fell*" (qualifies "spot"). Similarly with all clauses thus introduced by a relative pronoun (expressed or understood) or a relative adverb. Care must be taken, however, to distinguish such clauses from clauses involving an indirect question—as: "Tell me *where Nelson fell*," "I asked *where I was*," "I know *why you have come*." In these sentences the dependent clauses are substantival, representing substantives; there is no antecedent to which they can relate.

ADVERBIAL: "He died *while I was standing by*" (qualifying "died"); "We love Him *because He first loved us*" (modifying "love"); "Do *as I tell you*" (modifying "do").

EXERCISE.

Classify the subordinate clauses in the following extract from Scott's "Lay of the Last Minstrel," and parse the words in italics.

> "But when he reached the hall of state,
> *Where* she and all her ladies *sate*,
> *Perchance* he wished the boon *denied*;
> *For*, when to tune his *harp* he tried,
> His *trembling* hand had lost the ease
> *Which* marks security to please."

We conclude this course with a brief survey of the history of the English language.

Continued

FRENCH

Continued from page 1578

By Louis A. Barbé, B.A.

NUMERALS

1. Cardinal Numbers

1. The cardinal numbers (*adjectifs numéraux cardinaux*) are:

0, zéro
1, un
2, deux
3, trois
4, quatre
5, cinq
6, six
7, sept
8, huit
9, neuf
10, dix
11, onze
12, douze
13, treize
14, quatorze
15, quinze
16, seize
17, dix-sept
18, dix-huit
19, dix-neuf
20, vingt
21, vingt et un
22, vingt-deux
23, vingt-trois, etc.
30, trente
31, trente et un
32, trente-deux
33, trente-trois, etc.
40, quarante
41, quarante et un
42, quarante-deux
43, quarante-trois, etc.
50, cinquante
51, cinquante et un
52, cinquante-deux
53, cinquante-trois, etc.
60, soixante
61, soixante et un
62, soixante-deux
63, soixante-trois
64, soixante-quatre
65, soixante-cinq
66, soixante-six
67, soixante-sept
68, soixante-huit
69, soixante-neuf
70, soixante-dix
71, soixante et onze
72, soixante-douze
73, soixante-treize
74, soixante-quatorze
75, soixante-quinze
76, soixante-seize
77, soixante-dix-sept
78, soixante-dix-huit
79, soixante-dix-neuf
80, quatre-vingts
81, quatre-vingt-un
82, quatre-vingt-deux
83, quatre-vingt-trois
84, quatre-vingt-quatre
85, quatre-vingt-cinq
86, quatre-vingt-six
87, quatre-vingt-sept
88, quatre-vingt-huit
89, quatre-vingt-neuf
90, quatre-vingt-dix
91, quatre-vingt-onze
92, quatre-vingt-douze
93, quatre-vingt-treize
94, quatre-vingt-quatorze
95, quatre-vingt-quinze
96, quatre-vingt-seize
97, quatre-vingt-dix-sept
98, quatre-vingt-dix-huit
99, quatre-vingt-dix-neuf
100, cent
101, cent un
200, deux cents
201, deux cent un
1,000, mille
1,000,000, un million
1,000,000,000, un milliard

2. The old forms for 70, 80, 90, *septante*, *octante*, *nonante*, are seldom seen in print, but may occasionally be heard. Their derivatives:

septuagénaire, octogénaire, nonagénaire are still in common use to designate persons 70, 80, or 90 years of age. For *soixante* the corresponding form is *sexagénaire*.

3. The conjunction *et* is used in the first number of every new decade from *vingt et un*, 21, to *soixante et onze*, 71. It is not used after *t*, hundred ; *cent cinq*, 105 ; *cent vingt*, 120 ; ‥ by some it is again used after *mille*, 1,000: *les lle et une Nuits*, the Thousand and One Nights.

4. No preposition must be placed between he cardinal number and a noun ; but *de* is equired after *million* and *milliard*, which are really nouns : *Deux millions de francs*. For this reason they have *un* before them when used in the singular, and they take *s* when in the plural. *Cent* and *mille* are occasionally used as nouns of measure, and then follow the same rule : *deux cents de poires, un mille de fagots*.

5. *Vingt*, twenty, and *cent*, hundred, take *s* when they are multiplied by a number, but not followed by one. As regards *vingt*, *s* occurs in the one number 80 only : *quatre-vingts, deux cents* ; but *quatre-vingt-un, deux cent deux*.

6. When *vingt* and *cent* are used as ordinal numbers, or when they occur in dates, they do not take *s* : *l'an quatre-vingt*, the year 80 ; *l'an huit cent*, the year 800 ; *page quatre-vingt*, page 80 ; *page deux cent*, page 200.

7. When the word thousand occurs in a date of the Christian era, and is followed by another number, it is written *mil* : *mil neuf cent cinq*, 1905 ; but *l'an mille*, the year 1000.

8. The cardinal numbers, and not the ordinal as in English, are used to indicate the order of succession of sovereigns and the days of the month, after the first : *Charles deux, Henri quatre, le trente juillet, le quinze novembre*. In indicating the order of sovereigns, no article is used before the numeral. In indicating the day of the month, an article is used before the numeral, but no preposition after it.

9. In dating letters, figures are commonly used. The use of the article before them is optional. Sometimes *ce* (this) is used. Thus :

London, May 28th : *Londres*, 28 *mai*. *Londres, le* 28 *mai*. *Londres, ce* 28 *mai*.

10. In indicating the hour of the day, "twelve" is not used. *Midi* (midday), and *minuit* (midnight) are used instead.

11. In multiplying and adding, the verb *faire* (to make) is used instead of "to be."

Deux fois deux font quatre.
Twice (two times) two are four.
Neuf et sept font seize.
Nine and seven are sixteen.

II. Ordinal Numbers

1. The ordinal numbers (*adjectifs numéraux ordinaux*) are formed from the cardinals by adding *ième* : *troisième*, third ; *huitième*, eighth.

2. If the cardinal number ends in *e*, that *e* is omitted. The *s* of *quatre-vingts* is also dropped, *quatrième*, 4th ; *onzième*, 11th ; *quatre-vingtième*, 80th.

3. "First" is *premier* ; but the regular form, *unième* is used for the first of every decade from 21st to 61st, and also after *cent* and *mille*. *Vingt et unième, trente et unième, cent et unième, mille et unième*.

4. "Second" has the two forms *second*, (fem. *seconde*) and *deuxième*. *Second* is used of the *second* of two, *deuxième* of the second in a longer series.

5. In "fifth" the *u* which is the only vowel that can follow *q* is inserted : *cinquième*.

6. In "ninth," the final *f* of *neuf* is changed into *v* : *neuvième*.

7. *Premier* is used for "first" in indicating the order of sovereigns and the day of the month : *Charles premier, le premier janvier* ; but *le vingt et un juillet, le trente et un août*.

8. A special ordinal, *le quantième* (literally, the "how-*manieth*") is used for "the day of the month" ; thus : *Quel est le quantième* ? What day of the month is it ?

III. Fractions

1. The ordinal numbers are used as fractions, except in the case of $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{3}$, $\frac{1}{4}$, $\frac{3}{4}$. Thus : *un sixième*, $\frac{1}{6}$; *deux cinquièmes*, $\frac{2}{5}$.

2. "Half" is *demi*. It is masculine as an arithmetical value. When preceding a noun it is joined to it by a hyphen, and is invariable : *une demi-bouteille*, half-a-bottle. When it follows the noun it agrees with it in gender : *une bouteille et demie*, a bottle and a half ; *trois heures et demie*, three hours and a half. As a noun, "half" is *moitié* : *la moitié de la nuit*.

3. The "thirds" are *un tiers, deux tiers* ; the "quarters" are *un quart, trois quarts*.

Exercise XII.

1. Write out in French: 3, 5, 7, 11, 12, 15, 19, 21, 22, 30, 31, 44, 55, 58, 60, 69, 70, 71, 80, 89, 91, 99, 100, 210, 350, 789, 911, 999, 1,234.

2. Give French for : 1st, 2nd, (two ways), 4th, 5th, 9th, 20th, 21st, 32nd, 45th, 51st, 66th, 70th, 71st, 80th, 81st, 89th, 90th, 91st, 99th, 100th.

3. 1 and 1 are 2, and 2 are 4, and 4 are 8, and 8 are 16, and 16 are 32, and 32 are 64, and 64 are 128.

4. Twice 1 are 2 ; 3 times 2 are 6 ; 4 times 6 are 24 ; 5 times 24 are 120.

5. The minute contains (*contient*) 60 seconds.

6. The second is the 60th part (*partie*) of a minute.

7. (The) light takes (*emploie*) 8 minutes 13 seconds to come (*venir*) from the sun.

8. In an hour there are 60 minutes.

9. The day is a period (*espace*, m.) of 24 hours.

10. From midnight to midday there are 12 hours.

11. The year is composed of 365 days and a quarter.

12. The week (*semaine*, f.) has 7 days ; the month has sometimes (*quelquefois*) 31 days, sometimes 30 days, and sometimes 28 only (*seulement*).

13. The month of February, the second month of the year, has 28 days.

14. The year begins (on) the 1st of January ; it finishes (*finit*) on the 31st of December.

15. The month of December is the last month of the year.

16. The feast of Christmas falls always (on) the 25th of December.

Continued

XVIII. In the STRONG CONJUGATION OF VERBS [see X.] the characteristic features are the formation of the *imperfect* by *changing the stem-vowel*, and of the *past participle* by the suffix -en or -n with or without change of the stem-vowel, and with or without the prefix ge- [see XIV.]. The stem-vowel is also changed or modified in some cases of the *present indicative* and in the *imperfect conjunctive*.

1. The *present tense* of the verb ſchreiben, to write, may serve as an example for the inflections of the strong verb.

		Indicative		*Conjunctive*
Sing.	1.	ich ſchreib-e	I write	ich ſchreib-e
	2.	du ſchreib-(e)ſt	thou writest	du ſchreib-eſt
	3.	er ſchreib-(e)t	he writes	er ſchreib-e
Plur.	1.	wir ſchreib-en	we write	wir ſchreib-en
	2.	ihr ſchreib-et	you write	ihr ſchreib-et
	3.	ſie ſchreib-en	they write	ſie ſchreib-en

In the conjunctive the flective e can never be dropped; it is also better to retain it in the second person indicative of verbs with stems ending in hissing sounds: s, ſſ, ſch, z, where the omission would cause harshness—for instance: du ſchieß-eſt, thou shootest, and so on. In some of these verbs *both* forms are used, as: 1. ich vergeſſe, I forget; 2. du vergiſſ-eſt, du vergißt, and so on.

2. The majority of verbs with the stem-vowel a, au, and some with o (*a*) modify it, and others (*b*) change the stem-vowel e into i or ie in the second and third person singular of the indicative, and cast off the flective e.

EXAMPLES: (*a*) 1. ich grabe, I dig; 2. du gräbſt; 3. er gräbt. 1. ich fange, I catch; 2. du fängſt; 3. er fängt. 1. ich laufe, I run; 2. du läufſt; 3. er läuft, etc. (*b*) 1. ich fechte, I fence; 2. du fichtſt; 3. er ficht. 1. ich gebe, I give; 2. du giebſt; 3. er giebt.

(The conjunctive remains unaltered: 1. ich grabe; 2. du grabeſt; 3. er grabe, and so on.)

3. Several of the verbs mentioned in 2, with stems ending in t, th, and d, drop not only the flective e, but also the t of the inflection of the third person singular indicative: 1. ich rathe, I advise; 2. du räth(e)ſt; 3. er räth, and so on.

4. The *imperative* of the *strong verbs* is form… as in the weak conjugation [see XIV. 3 2nd per. sing. bleib(e)! stay, remain! 2nd p… sing. ſchreib! write! Civil address: bleiben … stay! ſchreiben Sie! write!

The verbs with the stem-vowel e change it… the singular into i or ie without suffix: fecht-… fence, ficht! geb-en, to give, gieb! eſſ-en, to ea… and so on. The circumscribed forms of th… perative are formed as in the weak conju… [see XIV. 4. 5].

XIX. The IMPERFECT INDICATIVE of… strong verbs is formed by changing the vow… in all persons and numbers; a further chan… of the *changed* vowel takes place in the pa… participle. The third person singular of t… imperfect indicative takes no inflection, an… the second person takes the inflection -eſt (aft… hissing sounds) or ſt: blaſ-en, to blow, 2nd per… sing. du blieſ-eſt, thou blewest; but: bleib-en, 2nd pers. sing. du blieb-ſt. The inflections of the plu… (1. -en, 2. -et, 3. -en) are to be seen below in th… conjugation of the imperfect of ſing-en, to sing which belongs to the group of verbs that change their vowel -i- in the imperfect into -a-, and change it further into -u- in the past particip… with the suffix -en and the usual prefix ge-. Th… present, imperfect, and past participle of ſinge… are: *pres.*: (ich) ſing-e; *imp.*: (ich) ſang; *p. past* ge-ſung-en.

IMPERFECT

		Indicative		*Conjunctive*
Sing.	1.	ich ſang,	I sang	ich ſäng-e
	2.	du ſang-ſt		du ſäng-eſt
	3.	er ſang		er ſäng-e
Plur.	1.	wir ſang-en		wir ſäng-en
	2.	ihr ſang-(e)t		ihr ſäng-et
	3.	ſie ſang-en		ſie ſäng-en

1. In the CONJUNCTIVE the verbs modify th… vowels (a, o, u, or au) of the imperfect indicative and take the same suffixes as the present tens… of the conjunctive [see example and XVIII… Some verbs with the imperfect vowel a a… (*a*) alternately used with the modified ä and … and others (*b*) take the modification ü instead o… ä. The form with ä in group (*a*) is usually n…

IMPERFECT

	Infinitive	*Indicative*	*Conjunctive*
To (*a*) belong:	beginn-en, to begin	ich begann	ich begänn-e or begönn-e
	beſinn-en, to reflect	,, beſann	,, beſänn-e or beſönn-e
	gelt-en, to be worth	,, galt	,, gält-e or gölt-e
	gewinn-en, to win	,, gewann	,, gewänn-e or gewönn-e
	ſpinn-en, to spin	,, ſpann	,, ſpänn-e or ſpönn-e
	ſchwimm-en, to swim	,, ſchwamm	,, ſchwämm-e or ſchwömm-e
	rinn-en to flow	,, rann	,, ränn-e or rönn-e
	befehl-en, to command	,, befahl	,, befähl-e or beföhl-e
	empfehl-en, to recommend	,, empfahl	,, empfähl-e or empföhl-e
	ſtehl-en, to steal	,, ſtahl	,, ſtähl-e or ſtöhl-e
	ſchelt-en, to scold	,, ſchalt	,, ſchält-e or ſchölt-e
(exception)	ſteh-en, to stand	,, ſtand	,, ſtänd-e or ſtünd-e
to (*b*) belong:	helf-en, to help	,, half	ich hülf-e
	ſterb-en, to die	,, ſtarb	,, ſtürb-e
	verderb-en, to spoil	,, verdarb	,, verdürb-e
	werb-en, to enlist	,, warb	,, würb-e
	werd-en, to become	,, ward	,, würd-e
	werf-en, to throw	,, warf	,, würf-e

employed where, in the pronunciation, the phonetic similarity of the imperfect conjunctive with other tenses of the same verb might lead to confusion, as in ich befähle, empfähle, stähle, schälte, which sound similar to ich befehle, empfehle, stehle, schelte. For the same reason the form with ä has been entirely abandoned in group (*b*).

2. Verbs which admit of *no modification* of the changed indicative vowel in the conjunctive form this tense by the suffixes shown in the conjugational example of XIX.

EXAMPLES: schreiben, imperfect indicative ich schrieb (ie not modifiable); imperfect conjunctive ich schrieb-e, etc.; beißen, to bite, imperfect indicative ich biß (i not modifiable); imperfect conjunctive ich biss-e.

Where the modified conjunctive vowel coincides with another tense, it is best to use the *first conditional* [see page 651] in the place of the imperfect conjunctive—*e.g*, in the verb schwör-en, to vow [imperfect indicative ich schwor (or schwur)]; the imperfect conjunctive, with modification of the vowel, ich schwör-e (or ich schwür-e) coincides with the present indicative. 1. ich schwör-e; 2. du schwör-st, etc. The employment of the first conditional „ich würde schwören“ [infinitive of the verb and imperfect conjunctive of the auxiliary verb „werden“] [see page 651] prevents misunderstanding.

XX. The ADVERBS are not, of course, subject to inflection by declension or conjugation.

Adverbs of place: hier, da, here; dort, da, there; oben, above; unten, below: vorn, in front, before; hinten, behind, after; innen, within; außen, out, without; fort, away, forth; weg, away, off; heraus', out; hin'ein, in, into; vor'wärts, forward, on; rück'wärts, backwards.

Adverbs of time: wann? when? dann, then; jetzt, now; soeben, just now; heu'te, to-day; ge'stern, yesterday; einst, once; da'mals, then, at that time; immer, stets, always, ever; selten, rarely; nie, nie'mals, never; zuwei'len, sometimes; schon, already; noch, still, yet; hierauf, hereon, hereupon: nun, now, at present.

Adverbs of manner, degree, quality, affirmation, negation, like: so, so, thus; sehr, very; ziemlich, tolerably, pretty; wenig, little, few; meist, meistens, most, mostly; umsonst', in vain; fer'ner, furthermore, besides; fast, beina'he, almost, nearly; kaum, scarcely; ganz, quite; nur, only, but; allerdings', surely, certainly; keinesfalls, keineswegs, by no means; vielleicht', perhaps; ungefähr, about; ja, yes; nein, no; nicht, not.

Adverbs of cause: darum, deshalb, therefore; folg'lich, consequently; also, thus; daher', thence; warum', wozu'? why?

1. Nearly all adjectives can be used adverbially without undergoing any change of form. In the sentence: Der Gärtner ist fleißig (the gardener is diligent) the adjective fleißig qualifies the substantive; whilst in der Gärtner a r b e i t e t fleißig (the gardener *works* diligent*ly*), it modifies as *adverb* the action expressed by the *verb*.

Some adverbs and adverbial denotations are formed from substantives, adjectives, and verbs by the suffixes -s, -st, -lich, -lings, etc.; (abends, or des Abends in the evening, of an evening; morgens, in the morning; jüngst, lately; freilich, certainly, indeed; neulich, recently; begreiflich, conceivably; meuchlings, treacherously; blindlings, blindly; etc.), or by connection with prepositions.

2. If a sentence opens with an adverb, the normal position of the finite verb is changed—the verb in this case must precede the subject. Examples: ich bin hier (I am here), but hier bin ich; er kommt nie (he never comes), but nie kommt er; der Gärtner arbeitet fleißig, but fleißig arbeitet der Gärtner. It will be seen that verb and subject are here in the same relative position as in the interrogative form [see IX.].

3. Some adverbs admit the use of the comparative and superlative, like the adjectives, but the formation of the adverbial superlative differs from the superlative in adjectives, as will be seen later.

EXERCISE 1: Fill in the missing verbs with their correct personal terminations. Strong verbs used in this Exercise (the imperfect vowel in brackets); beißen (i), to bite; betrügen (o), to cheat; binden (a), to bind; geben (a), to give; fahren (u), to drive; schlafen (ie), to sleep; laufen (ie), to run; helfen (a), to help; rufen (ie), to call; fechten (o), to fight; graben (u), to dig; fliehen (o), to escape.

Der Hund . . . . . ; er . . . . seinen Herrn. Du . . . . . .
The dog bites; he bit his master. Thou cheatest
dich selbst: Sie . . . . . . mich. Du . . . . . . Blumen;
thyself; you cheated me. Thou bindest flowers;
das Mädchen . . . . einen Kranz; der Vertrag . . . . ihn.
the girl bound a wreath; the agreement binds him.
Ich . . . . . ihm Geld, und er . . . . . . fort;
I gave him money, and he drove away;
ich . . . . . nichts; du . . . . . . mir das Geld,
I give nothing; thou givest me the money,
und er . . . . . . dir den Vertrag. Wir . . . . .
and he gives thee the agreement. We drove
fort und . . . . . .; ihr . . . . . ihn, aber er . . . . . .;
away and slept: you called him, but he slept;
du . . . . vorzüglich. Ich . . . . und er . . . .
thou sleepest excellently. I drove and he ran
fort. Du . . . . . . mich. Wir . . . . . . die
away. Thou scoldest me. We bound the
Blumen und ihr . . . . . uns. Wir . . . . . euch Alles,
flowers and you helped us. We gave you all,
doch ihr . . . . . . uns nichts; Sie . . . . . . , während
but you gave us nothing; you fought, whilst
ich . . . . . Er . . . . . mir und dann . . . . . . fort;
I slept. He helped me and then drove away;
du . . . . gut; er . . . . . . vorzüglich;
thou fightest well; he fights excellently:
ihr . . . . tapfer. Er . . . . . . mit (3) ihm
you (*pl.*) fight bravely, He drives with him
und . . . . . den Gärtner; sie . . . . . . mit ihm;
and calls the gardener; she escaped with him;
Sie . . . . . den Gärtner und . . . . . . ihm Geld;
you called the gardener and gave him money;
sie . . . . . . ihrem Manne; sie . . . . . . einander;
she helps her husband; they help one another,
Sie . . . . . . , du . . . . . . , er . . . . , wir . . . . ,
you (*pl.*) sleep, thou drivest, he runs, we dig.

Continued

Essential Qualifications of a Good Milliner. The Apprentice. Importance of Suiting a Customer's Style. Stitches and Accessories.

MILLINERY

MILLINERY is essentially a woman's profession, but to be successful she must have a light and delicate touch, accuracy and neatness, good taste in blending colours, a correct eye, judgment in adapting the style to the wearer, and a liking for working with dainty and pretty materials. Few tools are needed.

There are two seasons in the millinery trade, spring and autumn, with six to eight slack weeks in the summer and winter—July and August, and December and January.

The Apprentice. A girl of about 16, wishing to become a milliner, is usually apprenticed. The period is two years, in the second of which she receives about half-a-crown a week pocket-money. In some houses a premium is asked; others take girls without a premium, but through introduction. The girl is taken on approbation for some weeks to see if she has the necessary qualifications. At the end of the two years, if she has given satisfaction, she is usually taken on as improver, with a weekly salary starting generally at about 15s. a week. In the slack time some houses work their apprentices half time, or give them a holiday till the next season opens.

The head assistants and head milliners are engaged by the year, with salaries varying between two and five guineas a week.

It is well for a girl to be apprenticed to a small business, although it should be a first-class one, as she will then have a good opportunity of seeing all kinds of work done. In the larger houses the work is divided up into different branches, one room being set aside for making hats, another for toques and bonnets, and so on. An apprentice will never regret the time spent in matching—that is, obtaining from the warehouses patterns of silks, velvets, ribbons, etc., which tone exactly with a particular pattern. Until one has tried, it is difficult to realise how difficult some colours are to blend.

Advising a Customer. A milliner who thoroughly understands her work is able to advise her customers which of the many prevailing styles suits her, and a good business woman is sure to be a success.

Though the fashions change so rapidly many of the principles never change, and, when mastered, the worker will find herself able to adapt them to prevailing fashions.

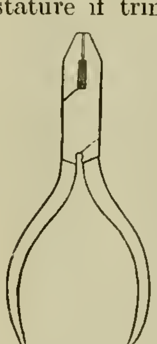
The importance of wearing what is really becoming without considering whether it is the latest fashion or not cannot be over-estimated. A clever milliner's aim is to adapt the prevailing fashions to suit the face.

Modern styles are so elastic that it is perfectly easy to be well dressed. No rules on how to dress can be laid down, but an important point to remember is that in choosing a hat or toque it is not only well to decide with what costume it will be worn, but, if possible, to try it on when wearing the dress. It will avoid possible disappointment, as that which looks well and in perfect style with a tailor-made costume may look small and insignificant when worn with an elaborately trimmed dress or big furs.

Hair-dressing and Millinery. The way in which the hair is dressed is another consideration in the choosing of headgear. The most fashionable headgear is modelled on the way the hair is dressed at the moment; thus, if the hair is worn low down at the neck, the brims will be long at the back. When the hair is worn at the top of the head, a short brim at the back with high crown, or a low crown and bandeau, looks best. For hair worn rolled back from the face, a turned up brim in front is most suitable.

Thin faces should have the hair dressed loosely over the temples, and a soft-looking edge to hat or full front to a bonnet. When no fringe is worn and the hair brushed smoothly back, a bonnet with rucked edge, or a brimmed hat, will be the best style to adopt. Hair dressed in coils and plaits at the back usually requires a large headline. Coils and plaits round the front require the headline cut rather wide there.

Large picture hats look well on tall people, though they may be worn by persons of small stature if trimmed very lightly. A hat should *never* be over trimmed.



1\. WIRE NIPPERS

A full face needs a broad trimmed hat.

A long face looks best in a brimmed hat, trimmed broad and worn over the face. High trimmings, which lengthen the face, should be avoided. Broad toques, fitting well on the head, may be worn.

The most becoming hat for a round face is a round hat with an equal brim all round, except at the back, and worn tilted slightly off the face in the front. No very small hats or toques are becoming to this style of face.

Drooping brims of the flop and mushroom type are not becoming to people past their youth, as they cast a shadow on the face. They are best suited to young, round faces.

Brims turned up in front can be worn by small round and oval faces.

Let your customer wear the colours that suit her. Do not advise her to wear a colour that

does not match her complexion, hair and eyes, no matter how fashionable.

The blonde may wear delicate shades of blue, pink, and green.

The brunette looks well in deeper and richer colours.

The choice of shades depends greatly on the complexion, as the colour may suit the hair but not the skin.

White is very becoming to fresh and rosy skins, but should be avoided by those with pale and sallow complexions.

Black is not becoming to pale and sallow complexions, unless combined with lace and a colour in the trimming. It looks well on fair people with a little colour in the face.

Requisites. We must now consider a milliner's "tools."

Gum or Gum Labels.

Tissue Paper.

Bowl and Damping Rags. For steaming and pressing.

Notebook and Pencil. For writing down measurements.

French "Doll's Head." Used for cap-stand.

Block for Shaping Crowns.

Kilting Machine.

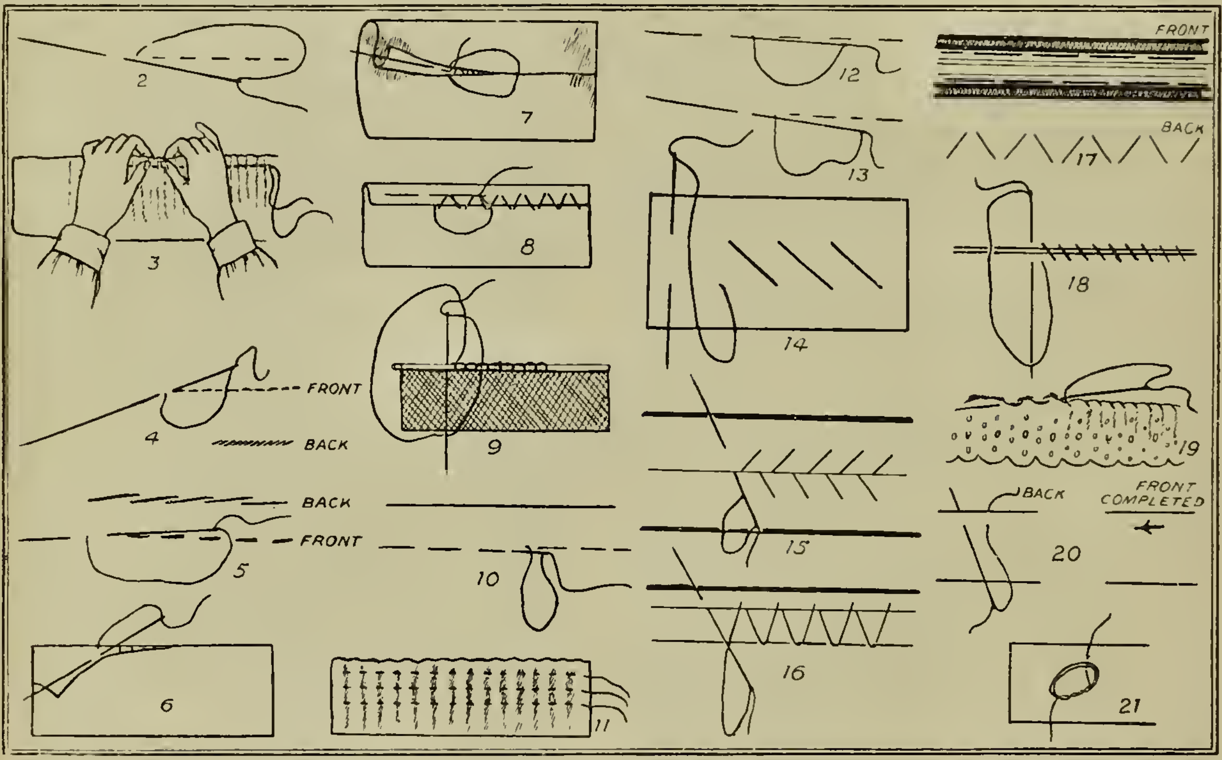
Accordion Pleating Machine.

Pinking Machine.

Velvet Brush.

Stitches. The following are the stitches used in millinery:

Running. Pass the needle and cotton in and out of the material at equal distances. The stitch appears the same on both sides. Used



2. Running 3. Fly running 4. Back stitching 5. Long back stitching 6. Slip stitching 7. Slip hemming 8. Velvet hemming 9. Wire stitching 10. Gathering 11. Shirring 12. Tacking 13. Tacking for crape 14. Basting 15. Lacing stitch 16. Catch stitch 17. Straight bandeau 18. Oversewing 19. Whipping 20. Tie stitch 21. Stab stitch

Millinery Wire Nippers. Price 1s. to 2s. 6d.; the latter are made of English steel. They must be light, small, and with broad noses [1].

Needles. Packet of straw needles, mixed, sizes, 5, 6, 8. Price 1d. No. 5 for wiring, and No. 8 for hemming.

Steel Pins. For pinning silk, velvet, etc.

Lillikins. For pinning velvet edges, joining laces, etc.

Thimble.

Scissors. About 7 in. long, with sharp points.

Tape Measure. Dean's are the best.

Sewing Cotton. Fine and coarse, white and black, No. 10 for sewing on trimmings.

Sewing Machine.

Flat Irons. No. 2 and No. 8, for pressing straw and steaming velvet, etc.

Ironing Blanket. For pressing.

Pocket-knife. For ripping fur.

for making the hem of head-linings, and joining two parts together where no great strength is needed [2].

Fly-running. Place the needle in the material and hold it lightly, close to the point, with the right thumb and forefinger. The thimble should propel the needle. The left hand holds taut the material, which is pushed on the needle by the left thumb and forefinger. As the needle fills with material, push it off from the eye end. The needle is not drawn through until the whole length is gathered. For long lengths, thread the needle from the reel of cotton or silk, which will prevent it knotting [3]. It is a rapid way of running, and is used for all branches of millinery that require gathering, such as tuckings, casings for silk hats and bonnets, tuck running in chiffon, tulle, etc.

Back Stitch. Insert the needle exactly where the last stitch was begun, and bring it out in front the same length as the stitch that has just been made.

To obtain a regular row of stitches, each stitch must exactly meet the last, and be of the same size [4]. Used for joining two pieces of velvet, silk, or cloth, wherever the material is likely to be stretched and requires strength.

Long Back Stitch. Instead of inserting the needle in exactly the place where the last stitch left off, as in back stitching, take a short stitch back, which in straw-working will be slanting in the direction the straw is plaited [5]. The long back stitch is used in straw-working, for sewing in head linings, bandeaux, mulling; in shape-making, for joining side band to head-line of brim shape; in covering, for sewing upper and under covering of brim to head-line, also material tip to that of shape.

Slip Stitch. Take one stitch on the turning of one piece of material, and the next exactly opposite on the turning of the other piece [6]. Used for joining the upper and under edges of hat-brims covered in velvet, cloth, or silk, and wherever invisible joining is required; also in stitching on rouleau to covered or felt hats.

Slip Hemming. Use a fine needle and cotton, or silk to match material, and take up one thread of the material under the fold. Slip the needle into the fold and make a short stitch as in running; draw the needle out, and just take one thread again of the material under the fold. Do not pull the stitches tight; they should not show on the right side [7]. The stitch is used for invisibly hemming velvet, silk, crape, etc.

Velvet Hemming. Turn down the raw edges of material once; take a stitch as in running through the fold, and take one thread of the material under the fold in a slanting direction. Work from right to left with fine needle and cotton [8]. Used for neatening cut edges of velvet, and where it does not require a roll hem.

Wire Stitch. Hold the wire firmly in place, stab the needle in the hat *above* the wire, holding back a loop of cotton under the thumb. Stab the needle back again *under* the wire, bringing it through the loop from behind, and pull tight. Work from right to left. The stitches must just fit the wire [9]. Used for all parts requiring to be wired.

Gathering. Take up half as much on the needle as has been passed over [10]. Used when a long length has to be gathered into a very small space.

Shirring. Rows of fine gathering placed underneath one another. The stitches must exactly correspond with the row above, and the cottons are drawn up together [11]. This stitch is used for fancy linings for brims, for children's millinery, etc.

Tacking. A large running stitch [12]. Used for keeping two parts temporarily together.

Tacking for Crape. A long and small running stitch [13]. Crape being a springy material, this stitch keeps it better in position than ordinary tacking.

Basting. A long and a short stitch, the first taken slantways, the second perpendicular [14]. Used for holding together temporarily the material and lining previous to being tacked.

Lacing Stitch. Place the needle under the fold, and bring out in a slanting direction. Place the needle in again on opposite side, also in a slanting direction [15]. Used for securing the raw edges of velvet folds. It is sometimes called Milliner's Herringbone, but it differs from the ordinary herringboning by being always worked from right to left.

Catch Stitch. Take the needle under the turning and bring out to right side. Pass under the wire, then over the wire, and under the turning again, and repeat [16]. Used for fastening down the upper side of material brim to the second edge wire of under brim.

Round Bandeau Stitch. The stitches are taken close to the edges of the ribbon wire to prevent curling up. Make a long stitch of ¾ in. on upper edge of ribbon wire. Bring thread to bottom edge of wire at the back, take the needle through at nearly half the length of the upper stitch already made. Then take another ¾ in. stitch, and so on. On the reverse side a series of ∧ ∧ will be seen. Use black cotton on white net and wire, and vice versa [17]. Used for sewing ribbon wire to net for foundation of round and straight bandeaux.

Oversewing. Place needle pointing straight towards you in the raw edge, hold the work round first finger of left hand. Repeat this, forming a slanting stitch from right to left on the right side, and a straight one between each [18]. Used for joining lace, sewing fur, neatening the raw edges of velvet for straight bandeau where a turning will make a very clumsy and thick effect.

Whipping. The needle is taken over the raw edge of the material, put in from back to front, and over the edge again. The stitches are taken fairly long, and the needle, as for "fly-running," is not taken out until the finish [19]. Used instead of gathering, to prevent ravelling in lace or tulle.

Tie Stitch. Stab the needle through from the right side; leave an end of cotton, bring back the needle from the back, and tie a knot [20]. Used for securing light trimmings, trails of flowers, lace, tips of feathers, loops of ribbon on a brim; fastening head linings in position inside bonnets and hats.

Stab Stitch. Proceed as with the tie stitch, but take the needle through and through the hat for extra strength [21]. Used for sewing on trimmings that require more strength than the tie stitch gives.

ANTOINETTE MEELBOOM

Copper Ore and Its Treatment. Electrolytic Copper. Alloys of Copper. Brass and Bronze. Working of Brass and Bronze.

COPPER AND ITS ALLOYS

COPPER, the symbol of which is Cu, and the atomic weight 63·1, was one of the earliest metals discovered by man. The Copper Age followed the Stone Age, and preceded the Bronze Age. Copper weapons have been found in Egypt at a depth which, assuming the present rate of deposit as fairly constant since it was left there, gives its time of manufacture as not less than 10,000 years ago. The occurrence of large copper masses in the metallic state, the colour of which renders it easily recognisable, drew early attention to copper.

Physical Properties of Copper. The colour of copper is a characteristic red, with a tendency towards purple when cuprous oxide is present. It is only a little softer than nickel and iron, of the useful metals. Its tenacity and extensibility give it great industrial value: it can be rolled, beaten, and drawn into very fine leaf and wire. The specific gravity of the ordinary copper of commerce is from 8·2 to 8·5, rolled and hammered copper having a higher specific gravity than cast or crystalline copper. Electrolytic copper is 8·95. Roberts-Austen gives the specific gravity as 8·82. The precise melting point of copper has not been determined, but is between 1,050° and 1,100° C. Molten copper is of a sea-green colour, and of great fluidity. The thermal conductivity of copper is 736 (silver = 1,000) and the electrical conductivity 97·61 (Roberts-Austen) (silver = 100). Copper can be welded only with difficulty, and then only at a bright red heat.

Chemistry of Copper. Copper is unaffected by atmospheric exposure at ordinary temperatures, but under the influence of damp or of carbon dioxide it becomes coated with *verdigris*, an impure acetate of copper. When heated to redness in air it develops copper scale, a dark layer consisting of cupric oxide on top and cuprous oxide below.

Copper is immune from attack by water free from air, and by lime water, hence the value of copper for kettles and other utensils, for boilers and for boiler tubes. It dissolves easily in ordinary nitric acid and aqua regia, but only slowly in sulphuric and hydrochloric acids. It is remarkable, however, that the strongest nitric acid does not act on copper. Under an electric current copper may be separated from impurities and deposited on the cathode as pure copper, the application of this principle constituting the process of electrolytic copper refining, which we shall consider later on.

Sources of Copper. Within a half century the world's supply of copper has multiplied by ten, but the world's demands have grown quite as much as the supply, and the present high price of the metal is evidence that it is far from overtaking the demand. The main though not the only reason for this increase in consumption has been the growth of the electrical industries, with their huge demands upon the copper market. As the electrical industries grow and spread, so will the need for copper increase, so that there is no present likelihood of pause in an expanding consumption. The relative importance of the copper sources has undergone change during the last few decades. Formerly the world looked to Chili as the most important source of supply, but to-day the United States of America, with the enormous copper wealth of Montana and the Lake Superior district, supplies 60 per cent. of the world's copper requirements, with Spain a good second.

Copper Ores. Copper is found both in the native state and in combination. The largest deposits of native copper known are in the Lake Superior district of North America. New Mexico and South Australia also possess important deposits and the copper sand of Chili contains from 60 per cent. to 90 per cent. of metallic copper.

Copper pyrites, or *chalcopyrite* ($Cu_2S.Fe_2S_3$), known also as *yellow copper ore*, is the source of most of the copper supply of the world. It has a yellow colour with a black streak, a hardness of 3·5 to 4, and a density of 4·1 to 4·3. It is found at Rio Tinto, in Spain, and in every one of the five continents. Cornish ores, and the large deposits of Montana and Alabama, are of this variety.

Malachite ($CuCO_3.Cu(HO)_2$) is a beautiful streaked green copper ore which is much used for ornamental purposes. Its hardness is 3·5 to 4, and its density 3·7 to 4·1. It occurs in the Ural district of Russia, in Chili, and in Arizona and New Mexico. It contains, when pure, 57·33 per cent. of copper, but is seldom found pure, being usually associated with salts of lime and magnesia, oxides of iron and manganese and other substances.

Cuprite, or *red oxide of copper* (Cu_2O), is of a red colour with a red-brown streak, a hardness of 3·5 to 4, and a density of 5·7 to 6·0. It contains 88·8 per cent. of copper, and occurs in Montana in the upper sections of Butte City veins, in New Mexico, and in Russia.

Azurite ($2CuCO_3.Cu(HO)_2$) is of a beautiful blue colour with blue streaks, has a hardness of 3·5 to 4, and a density of 3·5 to 3·8. It is usually present with malachite, but in much smaller quantities. It carries 55·16 per cent. of copper.

Bornite, or *eburesate* ($3Cu_2S.Fe_2S_3$), or *purple copper ore* (sometimes also called *peacock* ore) is of a brilliant purplish brown colour when uncovered, but exposure to the atmosphere speedily causes it to change, and it may become yellow or deep blue, green or purple. Its copper content varies from 40 per cent. to 70 per cent. Its hardness is about 3, and its density about 5. It is found in Montana, Cornwall, and Chili.

Chalcocite, or *copper glance* (Cu_2S), is of a streaked dark grey colour, has a hardness of 2·5 to 3, and a density of 4·8 to 5·8. It usually holds at least 55 per cent. of copper, and the deposits in Montana carry from 60 to 74 per cent. It is also found in quantities in Arizona, Colorado, and New Mexico, while smaller deposits are found in many other places

Treatment of Ores. The various ores of copper for metallurgical purposes may be classified into three groups. First there are the native copper ores, as found in the Lake Superior district, where the metal occurs in the form of metallic particles, and where the ore is concentrated mechanically, the resulting concentrate, or *mineral*, as it is termed, being melted down and toughened in refining

furnaces. Then the sulphide ores, the most important of which are copper pyrites, are subject to dry or wet processes, according to their nature and their copper contents. Dry methods are usually adopted with ores rich in copper and wet methods with poorer ores or with auriferous and argentiferous copper ores.

Chalcopyrite is a combination of copper with iron and sulphur, and the object in smelting is to separate the copper from these two and also, of course, to eliminate the gangue. The process depends upon the affinity of iron for oxygen and copper for sulphur. By calcination, or roasting the ores in heaps, or in shaft or reverberatory furnaces, they are freed from siliceous matter and concentrated, forming a copper *matte*, so-called. The matte is then smelted with a siliceous flux and oxide of copper is changed into a sulphide. Again it is fused with slag to oxidise the sulphide of iron and the result is a *white metal*, sometimes called *blue metal* or *fine metal*, with from 60 per cent. to 75 per cent. of copper. This is now melted in contact with air, and the oxide of copper formed reacts on the cuprous sulphide, forming an impure metallic copper (*blister* copper) and a slag rich in copper.

Copper Refining. The metal contains iron and other impurities, and has now to be refined. It is treated in a reverberatory furnace, and to remove the cuprous oxide poles of green wood are pushed into the bath, and charcoal or anthracite is sprinkled on the surface. When the metal has become pale and fibrous this refining is finished. The resulting copper ingot should show a flat surface. If it contain too much oxide it will be furrowed and is "underpoled," and if it be ridged on the surface it is "overpoled" and contains too little.

The modifications of this "reaction" process, as it is called, are numerous, and the varieties of furnaces and operations are very great. Each ore must be treated for its individual properties, and local conditions must also be considered. The "reduction" process is similar to the reaction process up to the "white metal" stage. The reduction process oxidises the sulphide completely, and reduces the mass by carbon. It is less economical than the other process.

The wet method of treating copper ore is followed for low grade ores. Copper sulphate is extracted from the roasted ore by bleaching with water, and the copper in solution is precipitated by the aid of another metal, usually iron, or by electrolysis. The great value of the wet process is that if the ore contain silver or gold these metals may be recovered.

Electrolytic Copper Refining. The electro-chemical treatment of copper ore has not yet been practised on a large scale, but electrolytic treatment of impure copper produces a copper of high purity, such as is required for electrical purposes. The principle of electrolytic refining of copper is simple. The electric current enters a bath of solution of sulphate of copper through an *anode* of impure copper and leaves it by a *cathode*. The action is that the anode is dissolved, but only the pure copper is deposited on the cathode, the remaining metals present as impurities, and also dissolved from the anode, not being so easily deposited as copper. We shall examine details of the process of electrolytic refining as practised in some of the largest works.

The first process in the electrolytic refining of copper is to melt the copper pigs or ingots so that they may be cast into the large flat plates which form the anodes in the electrolytic tanks. The charge of copper is melted in the *anode furnaces* as they are called, reverberatory furnaces used for this special purpose. Then the metal is worked by methods akin to those of puddling [see page 4635] for some hours, sometimes as many as thirteen or fourteen. This treatment dispels some of the impurities, and the copper is raised from usually 98·5 per cent. of purity to 99·5 of purity. Then the furnace is tapped, the metal is drawn off by the help of a ladle, and is poured into moulds which are mounted upon an endless chain. The copper plates which are to be used as anodes are 36 in. by 24 in. by 1 in. Each is made with two lugs on its upper edge, these being used to support the plate in the electrolytic tank. The plates are then put into frames holding 22 plates, the full charge for one electrolytic bath.

Electrolytic Bath. The tanks are filled with diluted sulphuric acid and sulphate of copp[er] electrolyte, and are usually arranged in sets wi[th] a reservoir and pump to each set. They are arranged electrically in series, and the electrodes in each tank are parallel.

The thin cathode sheets used in the depositing tanks are themselves deposited in other tanks known as *stripping tanks*. The cathodes in the stripping tanks are pure rolled copper plates covered with grease or plumbago, upon the surface of which the new plates form, and from which they are afterwards easily detached. These new plates are beaten with wooden paddles and are hung by copper loops from copper rods which lie upon the edges of the depositing tank.

Now the electric current is passed through the bath, and the action is to transfer the copper of the anode plates to the cathode plates, upon which it is deposited. The charge is under treatment in the electrolyte for seven days, when the cathode plates have increased from 6 lb. to 8 lb. in weight to 75 lb. or 80 lb. Then they are removed and taken to the refining furnaces. The anodes, however, are not yet exhausted. New cathode plates are supplied and the process is resumed. The anodes last for six weeks.

The final process of refining is similar to that already described, when the green wood is plunged beneath the surface so as to remove the oxide by the carbon of the wood combining with the oxygen and escaping as carbon dioxide. The result of the process is a copper of 99·88 per cent. of purity.

Copper Castings. Casting copper so as to give good sound castings is not an easy matter, but it is a subject of some importance because several industries, particularly the electrical industry, are developing an increasing need for copper castings. The chief difficulties in casting copper are occasioned by impurities in the copper, by the formation of cuprous oxide while the metal is in a state of fusion, whereby blow-holes are caused, and by the great contraction during cooling, whereby the mould is not completely filled. The first-mentioned difficulty is overcome to some extent by the use of copper which has been electrolytically refined, and is therefore chemically pure. A common method of overcoming the cuprous oxide difficulty, in good practice, is by casting in chills or dry sand moulds, and by adding up to 5 per cent. of manganese at the time of casting. Manganese combines with the oxygen of the cuprous oxide, thus making the metal more uniform. Sometimes zinc or tin, up to 1½ per cent., is added, and has the desired effect. For very thin or very sharp copper castings, the introduction of one-half of 1 per cent. of phosphorus has beneficial effects. It has a deoxidising effect, and increases the fluidity.

Copper Oxides. Numerous compounds of copper have a place in industry. We cannot go into great detail in every one of them, but we can pass them under cursory review and indicate their value and importance.

Cuprous oxide (Cu_2O), otherwise known as *red oxide of copper, copper suboxide,* and *copper hemioxide,* is found in the native state as cuprite or red copper ore [see page 1718], and as chalcotrichite. It may be prepared by heating finely divided copper in air below red heat and in several other ways. It is used as a pigment, and, in combination with black oxide of copper, constitutes one of the copper antifouling paints used for ship bottoms. It is also used in the manufacture of ruby glass.

Black oxide of copper (CuO), or copper monoxide, [illegible] found as *melaconite* or *black* copper in native [illegible]posits, prominently in the Lake Superior district. It is used in organic analysis. It is also used in the manufacture of green and blue glass [see GLASS].

Hydrated copper oxide ($CuO . H_2O$) is used in [illegible]per staining. It is of a blue colour, but develops [illegible] green under atmospheric exposure. Schweit[illegible]'s reagent, which is used in the manufacture of Willesden paper, is a solution of cupric hydrate in [illegible]ng ammonia. Treated with this solution [illegible]lose gelatinises and is completely solved. [illegible] the solution has been evaporated, a gummy [illegible] consisting of cellulose and copper oxide [illegible]ns. In making Willesden paper the solution is [illegible]ed to dry on the paper, making it water resisting and [illegible]ing the constituent fibres together, thereby [illegible]ing the strength. Ropes and netting are [illegible] by the same process. Thorpe quotes [illegible] best method of preparing hydrated [illegible] oxide: "Six parts of copper sulphate are [illegible] in water and mixed with a solution of [illegible] parts of calcium chloride. The clear liquid [illegible]ed from the precipitated calcium sulphate [illegible] mixed with one and a half parts of lime. [illegible] into a cream with water. The greenish [illegible] is collected, washed and mixed with [illegible] of its weight of slaked lime and as much [illegible], and to render the colour more permanent [illegible] of its weight of ammonium chloride [illegible]-half of its weight of copper sulphate are [illegible]ly added."

Chloride and Other Copper Salts. [illegible]swick green* of commerce is *cuprous* [illegible]Cl_2). It has a wide use as a pigment. [illegible] native as *atacamite.* It is prepared from [illegible] turnings by moistening them with hydro[illegible] or ammonium chloride under atmo[illegible]re, or it may be made by boiling [illegible] in solution with a small percentage [illegible] powder solution.

Cupric chloride ($CuCl_2$) is used for methyl violet in [illegible]co printing and for oxidising cutch colours. [illegible] heating copper in excess of chlorine [illegible] dissolving oxide of copper in hydrochloric [illegible]

Sulphate of copper ($CuSo_4 . 5H_2O$), or *blue vitriol,* as it is popularly known, is the most important salt of copper. It has many uses. In agriculture it is used for dressing wheat and other seeds. The practice is to soak the seeds in a weak solution of the salt within twenty-four hours of being sown. It is also applied to vines, usually as a solution of from 10 per cent. to 20 per cent. It is also applied to timber, and prevents rot. Sulphate of copper is also used in cotton printing, chiefly with potassium bichromate or iron mordants, and with logwood for black dyeing.

It is made from metallic copper, usually scrap copper, which is heated in a reverberatory furnace, sulphur being afterwards added and the doors shut. After some time the doors are opened and the heat is increased so as to oxidise the sulphide with sulphate. The hot mass is withdrawn, immersed in sulphuric acid (diluted), and, after settling, is decanted, concentrated and crystallised.

Cupric sulphide (CuS) is also used in calico printing for fixing aniline black. It is made in one way by precipitating a sulphate solution with sodium sulphide.

Nitrate of copper ($Cu(NO_3)_2$) has a limited use in cotton printing and textile dyeing. It is made by dissolving metallic copper or the carbonate or oxide in nitric acid.

Verdigris and Other Pigments. *Acetate of copper* is used as a pigment and in indigo dyeing as an oxidising agent. *Verdigris,* erroneously referred to by many authorities as a carbonate of copper, is a mixture of basic copper acetates, the mono-basic, dibasic and tribasic acetates being present in different proportions in different varieties of verdigris. The varieties of verdigris are used for oil and water colour paints, for the manufacture of emerald green and other copper paints, and in dyeing and calico printing. Green verdigris is manufactured commercially by placing copper sheets for some weeks between cloths moistened from time to time with pyroligneous acid or acetic acid. The verdigris forms as green crystals. Blue verdigris is made by allowing the refuse of the wine press—consisting principally of grape skins—to ferment, and by placing into this thin copper sheets. The copper sheets become coated with verdigris. They are allowed to remain in the mixture for about two to three weeks, and are afterwards left to stand and subjected to occasional moistening with water or wine during some two months. The verdigris is removed and squeezed into cakes.

Emerald green, referred to above and known also as *imperial green* and *Schweinfurth green,* is an *aceto-arsenate of copper.* It is a brilliant green of pleasing shade and is largely used. Wallpaper stained with this green is found to give off a peculiar odour when the wall is damp, and this is alleged to be poisonous. This pigment is manufactured by mixing boiling concentrated solutions of copper acetate and arsenious oxide. The volume is doubled by the addition of cold water, and the mixture is placed in bottles or flasks filled to the top so that premature crystallisation may not occur. Crystallisation takes place gradually, and is not complete for a few days. There are other methods of making the pigment, but that described yields the finest product.

Scheele's green is arsenite of copper. It was formerly in extended use but is now of little importance. It is made by adding arsenious oxide to a boiling aqueous solution of potassium carbonate; after filtering, this is added to an aqueous solution of copper sulphate and the arsenite of copper is precipitated.

Some basic *carbonates of copper* are known commercially as *verditer* green or blue and *Bremen* green or blue. They are used chiefly for paper staining. *Malachite* is a basic carbonate. Verditer is made commercially by grinding sea salt and blue vitriol with water and digesting the resulting paste in wooden boxes along with pieces of copper plates. When the chemical action is complete, hydrochloric acid is added with agitation. Caustic soda and water follow as an addition to the mixture, and the product is washed, filtered and dried.